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OREGON ONSITE EXPERIMENTAL SYSTEMS PROGRAM

by

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State of Oregon
Department of Environmental Quality
Portland, Oregon 97207

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Project Officer

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This study was initiated to develop useful design and performance data on alternative onsite wastewater treatment and disposal systems which would permit the use fo non-sewered technological solutions to residents of rural and suburban areas of the State of Oregon and the rest of the United States.

In order to exclude the possibility of system failure due to homeowner neglect or abuse, all systems were installed at homeowner's expense. The systems were chosen for the most part to suit the specific climate, soil conditions and topography of the location from a variety previously developed and locally conceived systems with varying degrees of modification to suit the application. Among the technologies evaluated were three types of sand filters, two types of evapotranspiration systems, mounds, biological ("composting") toilets, graywater systems, steep-slope systems, pressure distribution, tile-dewatering systems, and various combinations of the above.

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FOREWORD

The US Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimony to the deterioration of our natural environment. The complexity of that environment and the interplay between its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution and it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems for the prevention, treatment, and management of wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, for the preservation and treatment of public drinking water supplies and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research; a most vital communications link between the researcher and the user community.

This report relates the results of statewide study of alternative wastewater treatment and disposal technologies for individual homes. Because of the diversity of climate, soils and topography within the State of Oregon the results should have wider applicability beyond the borders of that state. Because more than one-fourth of the U.S. is not served by community-wide collection and treatment, the potential impact of the technologies studied should be significant. Further, the practical nature of this work should enhance its adoption by other states in a way that more theoretical studies cannot often achieve.

Francis T. Mayo
Director
Municipal Environmental Research Laboratory

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This study was initiated to develop useful design and performance data on alternative onsite wastewater treatment and disposal systems which would permit the use of non-sewered technological solutions to residents of rural and suburban areas of the State of Oregon and the rest of the United States.

In order to exclude the possibility of system failure due to homeowner neglect or abuse, all systems were installed at homeowner's expense. The systems were chosen for the most part to suit the specific climate, soil conditions and topography of the location from a variety of previously developed and locally conceived systems with varying degrees of modification to suit the application. Among the technologies evaluated were three types of sand filters, two types of evapotranspiration systems, mounds, biological ("composting") toilets, graywater systems, steep-slope systems, pressure distribution, tile-dewatering systems, and various combinations of the above.

Significant results of the study included the consistent capability of sand filters to significantly remove nitrogen, remove organics and suspended solids to extremely low levels, and forestall development of clogging mats in subsequent disposal trenches; the success of hand-dug systems on slopes up to 45 percent where soils were deep (> 5 ft); successful demonstration of the ability to pressure distribution to prevent groundwater contamination where the unsaturated soil depth exceeds 30 inches; the impracticability of evapotranspiration and mound systems in Oregon; and the substandard performance of some commercial graywater treatment systems compared to conventional septic tank and reduced (by hydraulic flow change) size disposal fields.

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Chapter 1

INTRODUCTION

Oregon's Administrative Rules for subsurface sewage treatment and disposal were developed in 1973 when Oregon law repealed State Health Division authority for this program. Jurisdiction was transferred to the Department of Environmental Quality (DEQ) and a statewide site evaluation and permit program was initiated. These rules specified minimum requirements in terms of soil, groundwater, landscape, and other parameters for approval for on-site subsurface sewage disposal. The rules included measurable site standards but also relied on interpretation and subjective judgment of soil, landscapes, and groundwater for site evaluation and design of on-site disposal systems.

The number of on-site subsurface sewage construction permits issued in Oregon increased from 8,645 in 1974 to 13,614 in 1978. A tightening economy caused a reduction in new construction in 1979, 1980 and 1981 and the number of on-site subsurface sewage construction permits dropped to 10,870, 8,529, and 5,653 respectively. In spite of this, many Oregon property owners and developers were not able to develop land and build homes because they could not obtain permits for on-site subsurface sewage systems. This situation aggravated the housing shortage, stimulated higher prices on existing housing, and increased pressure to develop prime agricultural land. These trends were in conflict with Oregon land use planning Goal 10 "to provide for the housing needs of the citizens of the state" and Oregon land use planning Goal 3 "to preserve and maintain agricultural lands". This conflict prompted the DEQ to develop alternatives to the standard septic tank and drainfield. In addition, suitable alternatives were needed to repair failing systems that were causing public health and groundwater problems.

The DEQ presented a request (SB 388) to the 1975 Legislature for $750,000 to retain Oregon State University to conduct a comprehensive study to:

(1) Analyze existing soil absorption systems to relate their performance to kind of soil, landscape, depth to groundwater, and other factors;

(2) Characterize bench mark soils statewide so that drainfield performance could be scientifically predicted from soil and site conditions; and

(3) Install and test a variety of experimental systems designed to overcome marginal soil and site conditions where standard systems could not be approved.

The 1975 Legislature did not fund this proposal. In spite of this, the DEQ initiated a nonfunded, scaled-down experimental program in 1975 which was subsequently funded jointly by the 1977 Oregon Legislature and the United States Environmental Protection Agency.

Direction and policy of the Experimental Sewage Disposal Systems program was spelled out in detail in Oregon Administrative Rules (Department of

Environmental Quality, 1978, Appendix A). Briefly, the intent of the program was to develop alternatives to the standard septic tank and drainfield through controlled experimentation. The DEQ identified problem soil areas, either with a history of failing systems or high denial rates, selected suitable sites according to defined criteria (Appendix B), designed alternatives to overcome site limitations, supervised construction, monitored system performance, evaluated data, and drafted rules to adopt alternatives that would function satisfactorily. The land owners installed systems according to plans and specifications and allowed DEQ access to monitor. In addition, the owners had to be willing to risk investing money on experimental systems that may fail.

Sufficient data have been collected to indicate that some systems functioned properly and others did not. As a result, mounds and evapotranspiration systems were dropped from the experimental program. The Oregon State Department of Commerce Plumbing Section assumed legal jurisdiction for composting toilets October, 1977. The Evapotranspiration-Absorption System was approved as Regional Rule C, July 1, 1979 and subsequently adopted as an alternative system March 13, 1981. The sand filter was adopted as an alternative system January 1, 1980 and the steep slope system, the tile dewatering system, the split waste system, and the low pressure distribution system were adopted as alternative systems March 13, 1981, and revised March 8, 1982 (Appendix C). As a result, the site evaluation approval rate statewide increased from 72% in 1978 to over 95% during the first half of 1981. These systems were dropped from the experimental program and new site selection criteria (Appendix D) were developed to reflect these changes.

A report on each individual kind of system appears in the following chapters. Soil and site conditions, acreage estimates and climatic information, where applicable, are discussed. System designs and monitoring methods are included. Performance is evaluated and discussed. Conclusions are drawn and recommendations made. In addition there is a chapter on Characteristics of Residential and Industrial Septic Tank Effluents and a chapter on Subsurface System Costs.

CHAPTER 2

RECIRCULATING SAND FILTER SYSTEMS

There are several million acres of soils in Oregon (1) with one or more limitations, other than slope that makes them not suitable for installation of standard onsite waste disposal systems. These soils are limited either by shallow depth to hard pans, claypans, saprolite, bedrock, and groundwater, or by permeability rates either too rapid for adequate treatment or permeability rates too slow for adequate disposal. Standard soil absorption systems were not permitted in these soils under Oregon Administrative Rules (2) because of a history of surface failure and the potential hazard of groundwater contamination. Recirculating sand filters, intermittent sand filters, and intermittent recirculating sand filters were installed in a number of these sites to determine if sand filter treatment was adequate to produce effluent of high enough quality to prevent surface failures and groundwater contamination from final disposal in a standard disposal field. This section discusses recirculating sand filter performance.

METHODS

Four recirculating sand filters were installed in Douglas County in Western Oregon. Sand filter system sites were located in foothills near the Eastern edge of Oregon's Coast Mountain Range.

RECIRCULATING SAND FILTER DESIGN

Recirculating sand filter design was similar to Hines and Favereau (3) using design characteristics in Table 2-1. A pit 12 ft x 12 ft x 4 ft excavated into natural soil and underlying geological material. The pit was lined with a 10 mil vinyl liner to prevent infiltration of groundwater.

TABLE 2-1. DESIGN CHARACTERISTICS FOR RECIRCULATING SAND FILTERS[1]

Surface Area	144 ft^2
Filter Media Depth	3 ft
Media Effective Size	1.2 mm
Media Uniformity Coefficient	2.0
Maximum Design Loading Rate	3.125 $g/ft^2/d$
No. Times Effluent Applied to Filter Before Discharge	3 to 4 minimum
No. Doses Per Day	48
No. Gallons Dosed/ft^2/Cycle	0.10-0.17 g/ft^2/dose
No. Gallons Applied/Dose	15 - 25 gal
Dosing Controls	Percentage

[1] All sand filters were designed to process up to 450 gal septic tank effluent per day.

A 4 in. perforated underdrain was placed in the bottom of the sand filter container and covered with about 8 in. of 3/4 in. washed gravel. The filter container was then filled with 3 ft of nickel mining slag with an effective size of 1.2 mm and a uniformity coefficient of 2.0. The distribution system was installed above the sand filter bed (Figure 2-1). Very coarse sand sized media was used to allow filters to continuously receive wastewater at a high hydraulic loading rate and still maintain aerobic conditions for rapid treatment of septic tank effluent.

Filter systems were designed so household wastewater, first treated by a septic tank, drained into a recirculating tank. Each half hour, approximately 20 gallons of wastewater were pumped from the recirculation tank to the open filter surface. Pump cycles lasted 5 minutes. A 25-minute resting period followed each pump cycle (Table 2-1). Pumping events were regulated by time clock controls. Pumped effluent was distributed to the exposed filter surface from 10 ft long, half sections of 4 in. diameter plastic pipes with downturned 1/2 in. holes on 5 in. centers. Distribution piping was positioned immediately above the filter surface. Piping was supported by trestles made of steel rebar anchored in the filter media (Figure 2-1). After effluent drained through 3 ft of filter media and 1 ft of gravel, it entered a 4 in. diameter perforated plastic pipe underdrain at the base of the vinyl liner. Effluent collected in the underdrain flowed back to the recirculation tank. Within the recirculation tank, a custom-made downturned ball check valve attached to the underdrain return piping regulated whether filtrate drained back into the recirculation tank or bypassed to disposal trenches. When the liquid level in the recirculation tank was low enough to permit a ball to hang loosely below a downturned "tee" opening, filtered effluent entered the recirculation tank. When the liquid level rose sufficiently to cause the ball to float securely against the "tee" opening, effluent bypassed the recirculation tank and discharged to 2 ft deep, 2 ft wide soil absorption trenches which contained 4 in. diameter perforated plastic distribution piping bedded in 12 in. of washed gravel.

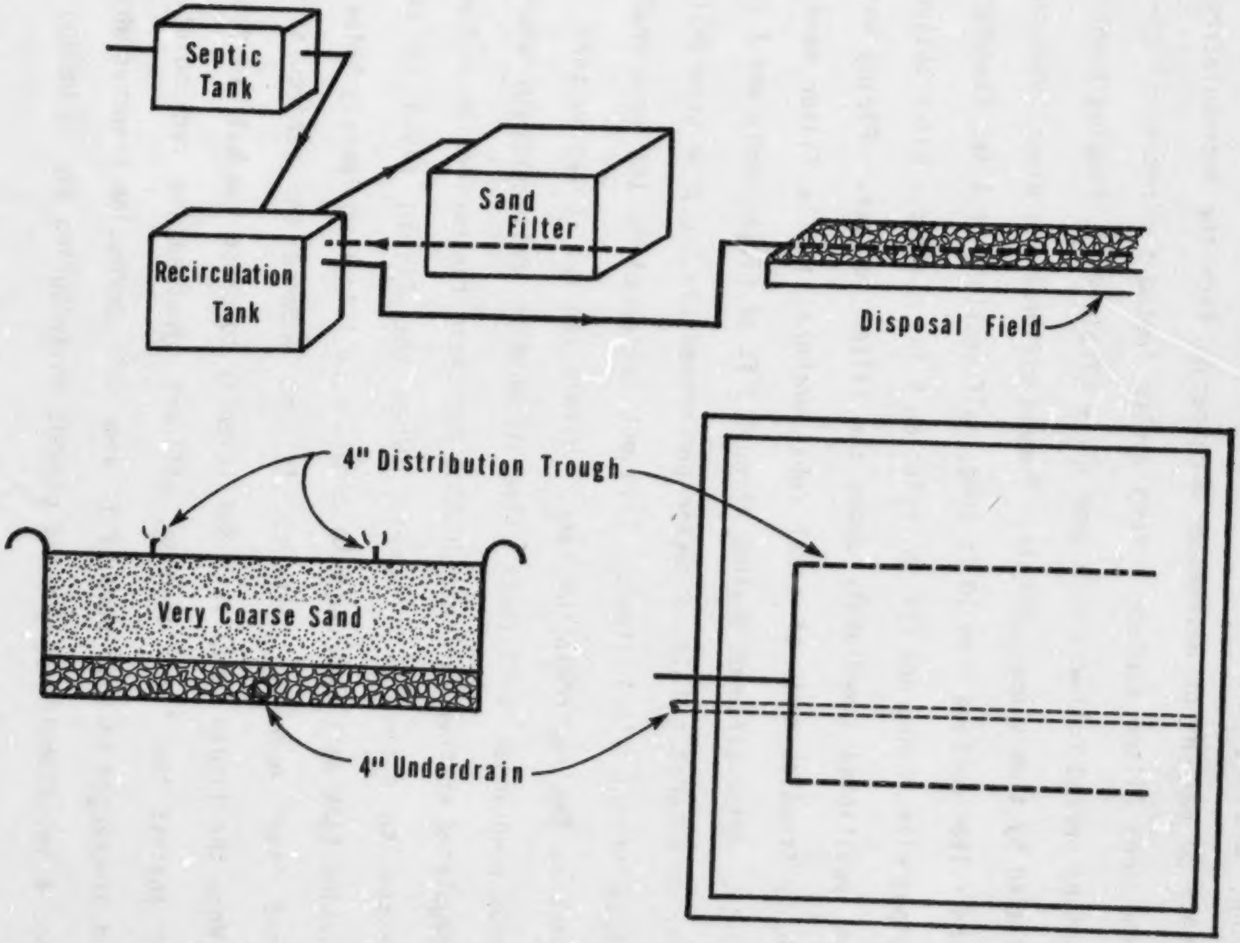
Septic Tank
Sand Filter
Recirculation Tank
Disposal Field
4" Distribution Trough
Very Coarse Sand
4" Underdrain

FIGURE 2-1. RECIRCULATING SAND FILTER

MONITORING

Average daily sewage flow was 209 gallons and the average daily filter loading rate was 1.45 gal/ft^2 (Table 2-2).

TABLE 2-2 AVERAGE DAILY SEWAGE FLOWS AND LOADING RATES FOR RECIRCULATING SAND FILTERS

SYSTEM	DAILY FLOW (gpd)	FLOW/FILTER SURFACE (g/ft^2/d)
1 (Stratton)	246	1.71
2 (Moody)	127	0.88
3 (Triplett/Perry)	255	1.77
Mean Values	209 (3)[1]	1.45 (3)

[1] Number of samples.

Filters were monitored to determine their mechanical operation and maintenance needs as well as their capacity to treat septic tank effluent. Effluent samples were collected and analyzed for BOD_5, SS, NO_3, NO_2, NH_3, total kjeldahl nitrogen (TKN), total nitrogen (TN), fecal coliform (FC), and total coliform (TC). Nitrate + nitrite-nitrogen was determined by the hydrazine reduction method, nitrite-nitrogen was determined through automated analysis by technicon, ammonia-nitrogen was determined by the phenate colorimeteric method, and total kjeldahl nitrogen samples were digested in a technicon block digester and analyzed by the automated phenate method (4). Suspended solids were determined using U.S. EPA methods for chemical analysis of water and wastes (4). BOD_5 was determined by the Modified Winkler method and fecal and total coliforms were determined using the membrane filter method (5).

Disposal trench absorption rates were determined during the summer months when disposal trenches were not inundated by seasonal groundwater.

RESULTS AND DISCUSSION

OPERATION AND MAINTENANCE

Recirculating sand filter surfaces were subjected to accumulation of leaves and other fallen debris and vegetative growth. Algae, mosses, grasses, and many other weed varieties grew abundantly on filter surfaces during spring, summer, and early fall months. Leaf litter, other organic debris, algae, and thick mats of moss also accumulated in filter distribution troughs. Accumulated materials clogged distribution trough drain holes when troughs were not maintained (Table 2-3).

In mid-October 1979, Douglas County engineering staff reconstructed System 3's effluent distribution system, replacing distribution troughs with a grid network of 16 shrub spray heads. After 6 weeks operation, half the shrub spray head orifices were clogged with organic matter.

Removal of leaves and other wind blown litter was required at least once each fall. Filter surface weeding and distribution trough cleaning was required at least twice annually, once during the spring and once during summer months.

No maintenance was carried out on the filter surface and distribution piping of System 1 to determine the effect of litter and vegetative growth on filter operation. During the monitoring period, weeds covered up to 60% of the filter's surface and the system's 2 distribution trough perforations were clogged causing recirculated effluent to discharge from a single place on the edge of each trough. In spite of this, effluent from the recirculation tank continued to be accepted by the filter without ponding.

After filters had been in operation for a few months, wood frame box structures covered by screen and hardware cloth were located over filter surfaces to prevent access by animals and children and prevent debris from falling onto filter surfaces. Even though filters were protected by these structures, distribution trough alignment was easily disrupted. When out of alignment, all effluent drained to the filter surface from one end or edge of each trough. Although troughs could be easily returned to their proper positions on supportive rebar trestles, system users failed to realign distribution piping once it was out of alignment.

Faint ammonia odor was detectable near all recirculating sand filters during winter months (Table 2-3). In addition, a slight sewage odor was apparent at System 1.

Pump failure occurred twice at System 4 (Table 2-3). The pump's electrical system failed when control wiring, exposed to corrosive gases, shorted.

SAND FILTER EFFLUENT QUALITY

Recirculating sand filters reduced BOD_5 99% and decreased SS by 97% (Table 2-4). Total nitrogen was reduced 45%. Ninety-five percent of the

TABLE 2-3. RECIRCULATING SAND FILTER OPERATION AND MAINTENANCE NEEDS

SYSTEM	ALGAE (A), MOSS (M), WEEDS (W)/LEAVES (L) ON FILTER SAND SURFACE	DISTRIBUTION TROUGH ORIFICES CLOGGED BY ORGANIC MATTER	FILTER DISTRIBUTION TROUGHS KNOCKED OUT OF ALIGNMENT	ODOR	PUMP FAILURE	MONTHS OBSERVED	TIMES OBSERVED
1 (Stratton)	Yes (A)(M)(W)(L)	Yes	Yes	Yes; slight sewage and NH_3 in winter	No	46	18
2 (Moody)	Yes (W)	Yes	Yes	Yes; slight NH_3 in winter	No	48	16
3 (Triplett/ Perry)	Yes (A)(M)(W)(L)	Yes	No	Yes; slight NH_3 in winter	No	45	91
Baylis	Yes (W)(L)	Yes	Yes	Yes; slight NH_3 in winter	Yes; control wiring failure, 2 times	10	8

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nitrogen in sand filter effluent was in the nitrate form compared to less than 1% in septic tank effluent.

TABLE 2-4. A COMPARISON BETWEEN SINGLE FAMILY RESIDENTIAL SEPTIC TANK EFFLUENTS AND RECIRCULATING SAND FILTER EFFLUENTS[1]

EFFLUENT CHARACTERISTIC	SEPTIC[2] TANK EFFLUENT	RECIRCULATING[3] SAND FILTER EFFLUENT	% CHANGE
BOD_5	217 (70)[4]	2.7 (82)	99
SS	146 (70)	3.8 (82)	97
NO_2	0.02 (57)	0.06 (28)	67
NO_3	0.4 (59)	29.9 (51)	99
NH_3	40.6 (60)	0.45 (51)	99
TKN	57.1 (57)	1.1 (51)	98
TN	57.5 (54)	31.5 (51)	45
FC	2.6×10^5 (56)	8.5×10^3 (109)	97 (2 logs)
TC	1.32×10^6 (46)	1.0×10^4 (46)	99 (2 logs)
Number Systems	8	4	

[1] BOD_5, SS and nitrogen expressed as mg/l; arithmetic mean. Fecal and total coliform expressed as org/100 ml; geometric mean.
[2] Arithmetic mean of 8 systems (Table 2-5).
[3] Arithmetic average of 4 systems.
[4] Number of samples.

Total nitrogen in sand filter effluent fluctuated seasonally (Table 2-6) from a low of 23.59 mg/l in cool moist months (November to April) to a high of 36.80 mg/l in warm dry months (May to October). These data and precipitation records (Figure 2-2) suggested that rainfall dilution was responsible for the apparent decrease of total nitrogen during the November to April period. Nitrate-nitrogen concentrations were 36% lower in cool, moist months than they were in warm, dry months (22.55 mg/l compared to 35.50 mg/l).

TABLE 2-5. CHARACTERISTICS OF 8 OREGON SINGLE FAMILY RESIDENTIAL SEPTIC TANK EFFLUENTS

SYSTEM	AVE. FLOW (gpd)	SEPTIC TANK EFFLUENT CHARACTERISTICS[1]								
		BOD_5	SS	NO_3	NO_2	NH_3	TKN	TN	FC	TC
1 (McCurley)	191	149 (8)[2]	240 (8)	0.18 (9)	0.02 (9)	37.8 (9)	56.9 (9)	57.1 (9)	2.0×10^4 (10)	1.5×10^5 (8)
2 (Gilkey)	113	197 (11)	38 (11)	0.81 (10)	0.02 (10)	35 (10)	58.4 (10)	59.20 (10)	1.1×10^5 (10)	1.8×10^6 (9)
3 (Grooms)	139	188 (7)	79 (7)	0.04 (7)	0.02 (6)	35.5 (7)	45.6 (7)	45.67 (6)	7.0×10^4 (6)	7.7×10^5 (5)
4 (Boettcher)	194	222 (11)	193 (11)	-	-	-	-	-	-	-
5 (Reber)	176	378 (7)	276 (7)	0.16 (6)	0.03 (7)	53.3 (7)	71.8 (6)	71.9 (5)	5.4×10^5 (6)	2.1×10^6 (6)
6 (McClaflin)	161	125 (16)	91.7 (16)	0.56 (16)	0.02 (15)	36.1 (16)	51.30 (16)	51.80 (15)	8.0×10^4 (14)	9.9×10^5 (10)
7 (Roberts)	174	348 (7)	171 (7)	0.38 (8)	0.02 (7)	55.9 (8)	70.5 (7)	70.9 (7)	1.0×10^6 (8)	2.5×10^6 (6)
8 (Anderson)	---	322 (3)	203 (3)	0.24 (3)	0.02 (3)	32.56 (3)	47.2 (2)	47.45 (2)	8.1×10^4 (2)	1.3×10^6 (2)
Weighted Arithmetic Average	164 (7)	217 (70)	146 (70)	0.4 (59)	0.02 (57)	40.6 (60)	57.1 (57)	57.5 (54)	2.6×10^5 (56)	1.32×10^6 (46)

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[1] BOD_5, SS, and nitrogen expressed as mg/l; arithmetic mean. Fecal and total coliform expressed as org/100 ml; geometric mean.

[2] Number of samples.

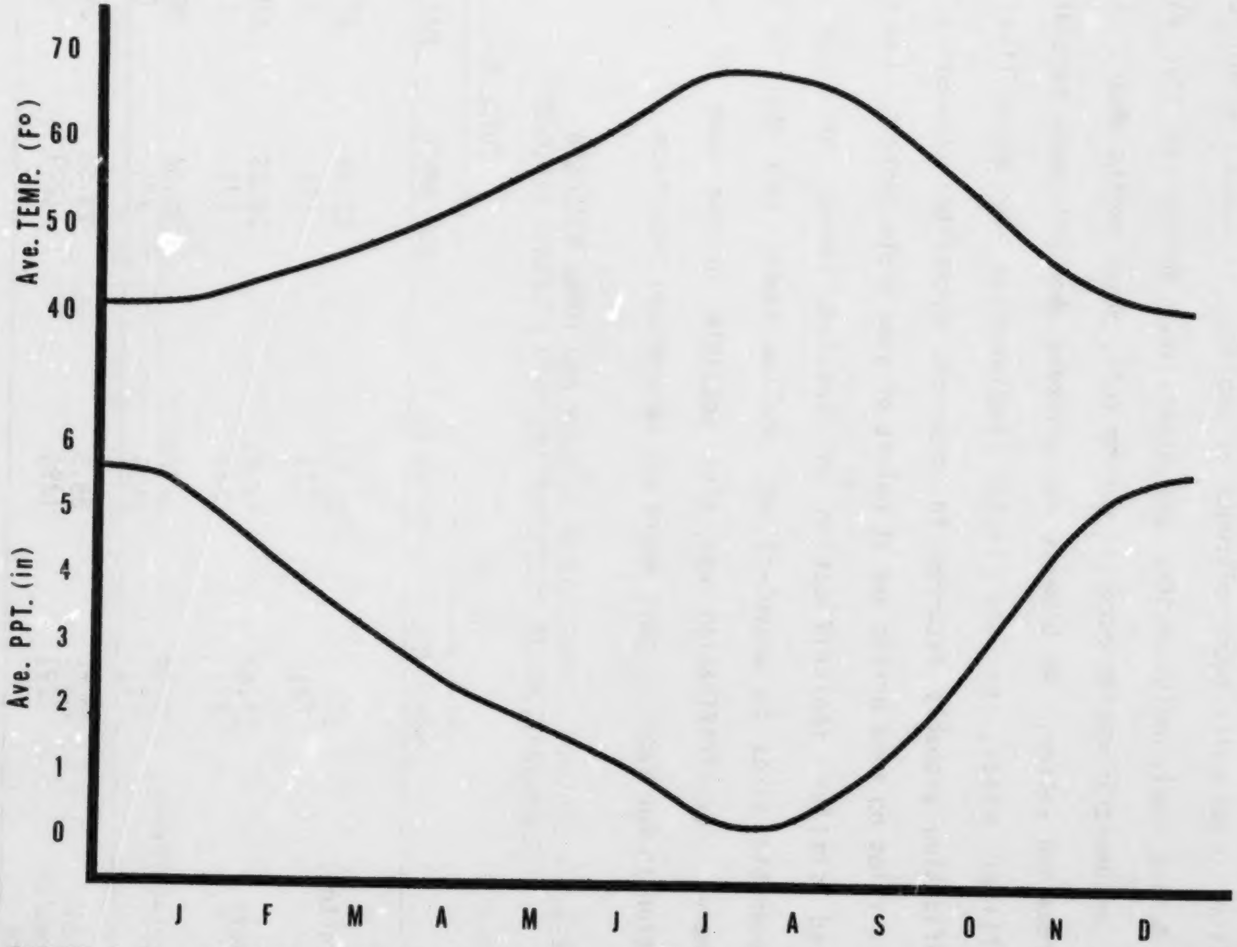

FIGURE 2-2. AVERAGE MONTHLY TEMPERATURE AND PRECIPITATION RECORDED AT THE ROSEBURG MUNICIPAL AIRPORT, DOUGLAS COUNTY, OREGON, BETWEEN 1900 AND 1957 (6).

Organically bound and free ammonia nitrogen concentrations during these periods remained relatively constant (Data not shown). This suggested, that either organically bound nitrogen accumulated as biomass within the filter during cool, moist months and mineralized during the dry, warm months, or denitrification occurred during cool, moist months when filter media remained wetter. No biomass was observed when pits were excavated into filter sands, so the latter explanation is more likely. Denitrification probably occurred in anaerobic microsites consisting of moisture films on sand grains and at points of sand grain contact. Law (7) reported similar denitrification of treated sewage occurred in microanaerobic sites in gravel-filled, shallow tanks, left open to the atmosphere. Denitrification was also possible in the zone of near saturation in the sand bed just above the sand-gravel interface.

TABLE 2-6. A SEASONAL COMPARISON OF NITRATE AND TOTAL NITROGEN CONCENTRATIONS IN RECIRCULATING SAND FILTERED EFFLUENT[1]

	NO_3-N		TOTAL N	
SYSTEM	NOV-APRIL	MAY-OCT	NOV-APRIL	MAY-OCT
1 (Stratton)	12.2 (8)[2]	26.53 (3)	12.94 (8)	27.27 (3)
2 (Moody)	27.82 (7)	49.46 (3)	28.85 (7)	50.49 (3)
3 (Triplett/Perry)	29.14 (7)	34.87 (23)	30.54 (7)	36.27 (25)
Weighted Arithmetic Average	22.55 (22)	35.5 (29)	23.59 (22)	36.80 (29)

[1] Nitrogen concentrations expressed as mg/l; arithmetic mean.

[2] Number of samples.

A small amount of nitrogen loss may also have been due to ammonia volatilization, particularly during warm dry months, but data does not support this hypothesis.

Recirculating sand filters reduced total and fecal coliform organisms by an average of 2 logs (Table 2-4). The rate of flow and the number of passes through filter media determined the level of bacterial removal (Data not shown). Flow rates through treatment media were controlled by media texture and pore size. Very coarse sands allowed rapid percolation of effluent, resulting in limited filtering of bacteria and little time for bacterial reduction to take place.

Surprisingly, effluent distribution efficiency and clogging of distribution troughs by weeds had little measurable impact on effluent quality. Even after holes in filter distribution troughs became clogged by organic debris, causing effluent to spill onto the filter surface at 1 or 2 points at the edges of distribution piping, no difference in effluent quality was detected at System 1. When piping was out of alignment, causing effluent to spill from a small region toward the end of each pipe, no decrease in effluent quality was observed. Although vegetation eventually covered approximately 60% of filter surfaces, no adverse effect on treatment was discernible. When filter effluent distribution troughs at System 3 were replaced by 16 shrub spray heads, effluent distribution uniformity vastly improved (visual observation). However, the change in distribution did not result in any measurable effect on improving effluent quality (Data not shown).

DISPOSAL FIELD PERFORMANCE

In spite of the fact that absorption trenches were placed on sites which were severely limited by shallowness to groundwater or rock or slowly permeable soils, all disposal fields functioned satisfactorily. No surface failures occurred and disposal trenches accepted effluent at the rate of 1.89 to 2.8 gal/ft^2/d (Table 2-7). Disposal trenches at System 3 were installed to replace a failing (surfacing) disposal field. Trenches were installed at the same time the repair sand filter was constructed. They showed no signs of failure during or after 47 months use in spite of the fact trench sidewalls were completely or partially inundated by surface water infiltration 3-5 months each year. Throughout that time, trenches received an average of 255 gal sand-filtered effluent per day.

Wert (13) reported that treatment of septic tank effluent by sand filtration substantially reduced the rate of soil clogging. Although investigators disagree on which causative agent plays the most active role in clogged mat development, they all agreed that BOD_5, SS, and fecal bacterial organisms were primarily responsible (8, 9, 10, 11, 12). Sand filtration markedly decreased all of these constituents (Table 2-4).

Table 2-8 compares the mean rates sand filter effluent was accepted by silty clay loam and silty clay soils at three filter sites with septic tank effluent loading rates Bouma (14) and Machmeier (15) recommended for much deeper, better drained soils of similar texture. The effluent acceptance rate shown for System 2 was conservative. The first disposal trench at

TABLE 2-7. A DESCRIPTION OF SITE CONDITIONS, SOIL ABSORPTION TRENCHES, AND TRENCH PERFORMANCE AT RECIRCULATING SAND FILTER SYSTEM LOCATIONS

FEATURE DESCRIBED	SYSTEM 1 (STRATTON)	 2 (MOODY)	 3 (TRIPLETT/PERRY)	 4 (BAYLIS)
Soil Absorption System Site Limitation	Slowly permeable claypan at 10-19 in., weathered basalt at 20-36 in.; perches seasonal water table at 10 in.	slowly permeable claypan at 20 in.; suspected seasonal groundwater	Seasonal groundwater table at 13 in.	10-20 in. to weathered basalt
Soil Texture at Absorption Trench Sidewall	19 in. silty clay over weathered basalt; 10-15 in. silty clay over clay	20 in. silty clay loam over clay	Silty clay loam	10-20 in. loam over weathered basalt
Slope (%)	15-20	4	10-17	12
Ave. Drainfield Loading Rate (gpd)	246	127	255	—
Trench Type, Length,[1] and Sidewall Absorption Area (ft^2)	3-serial trenches 300 lin. ft (600)	3-serial trenches 150 lin. ft (300)	3-serial trenches 375 lin. ft (750)	3-serial trenches 150 lin. ft (300)
Ave. Daily Trench[2] Sidewall Loading Rate ($g/ft^2/d$)	1.89	2.5	2.8	—
Ave. Percent System[3] Sidewall Used for Absorbing Effluent	8.3	16.6	8.3	Not determined
Trench Installation Date	May 1977	November 1976	August 1976	April 1977
Observation Period	May 1977-March 1981	March 1977-March 1981	March 1977-Feb. 1981	April 1977-Feb. 1978
Number of Observations	18	29	81	11

---

[1] Average trench depth was 24 in.; trenches contained 12 in. washed gravel and were gravity fed through 4 in. diameter perforated plastic distribution piping.

[2] The majority of the effluent at the Stratton system appeared to be absorbed by the weathered basalt.

[3] Average percent sidewall used for absorbing sand filtered effluent was determined during dryer summer months at the Stratton and Triplett sites since sidewalls were often partially or totally inundated by groundwater during high rainfall months (November-April). Percent sidewall absorption area used to absorb effluent determined in wet winter months.

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that system was not uncovered and no monitoring well was placed in the trench, so the actual trench liquid level of that system was not determined. However, effluent did not reach the system's second drop box.

Acceptance rates in Table 2-8 assumed 6 in. of the trench sidewall was continuously inundated. Wert (13) estimated the silty clay horizon in System 1 accepted effluent at a rate of 0.2 gal/ft^2/day and the basalt saprolite accepted effluent at the rate of 1.69 gal/ft^2/day. The effluent acceptance rate varied along the 125 ft disposal trench in System 3 but averaged 2.8 gal/ft^2/day (13) in a silty clay loam trench sidewall.

Patterns of unequal effluent acceptance were reported by other investigators in silty soils (16). Zones of highest permeability occurred where the soil contained a large number of macropores.

TABLE 2-8. A COMPARISON BETWEEN RECIRCULATING SAND FILTER SOIL ABSORPTION TRENCH EFFLUENT ACCEPTANCE RATES AND SEPTIC TANK EFFLUENT LOADING RATES RECOMMENDED BY BOUMA AND MACHMEIER IN SIMILAR SOILS

			RECOMMENDED SEPTIC TANK[2] EFFLUENT LOADING RATE (g/d/ft^2)	
SYSTEM	SOIL TEXTURE	FILTERED[1] EFFLUENT ACCEPTANCE RATE (g/d/ft^2)	BOUMA	MACHMEIER
1 (Stratton)	silty clay over basalt saprolite and clay	1.89[3]	0.24	0.45
2 (Moody)	silty clay loam over clay	2.5	0.72	0.50
3 (Triplett/ Perry)	silty clay loam	2.8	0.24	0.45

[1] Based on sidewall area.
[2] Based on bottom area.
[3] The first 60 ft of trenches were located in 19 in. silty clay covered weathered basalt. The last 40 ft of trenches were installed through 10-15 in. silty clay over 10-25 in. clay over weathered basalt.

CONCLUSIONS

The surfaces of recirculating sand filters were subject to accumulation of leaves, other fallen debris, and vegetative growth which tended to clog the effluent distribution system. In spite of this, there was no measurable impact on treatment.

BOD_5, SS, and total nitrogen were reduced 99%, 97%, and 45% respectively. Denitrification probably occurred in anaerobic moisture films on sand grains and at points of sand grain contact and in the zone of near saturation just above the sand-gravel interface.

Total and fecal coliform organisms were reduced by 2 logs.

Sand filtration of septic tank effluent significantly increased the disposal trenches effluent acceptance rate.

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CHAPTER 3

INTERMITTENT SAND FILTER SYSTEMS

Intermittent sand filters were installed and monitored under the same conditions as recirculating sand filters. Site limitations and affected acreages were discussed previously (Chapter 2). This section reports on intermittent sand filter treatment of septic tank effluent prior to discharge into disposal trenches installed either in soils shallow to hardpans, claypans, saprolite, bedrock, and groundwater, or in soils with permeability rates either too rapid for adequate treatment or too slow for adequate disposal.

METHODS

INTERMITTENT SAND FILTER DESIGN

Seven intermittent sand filters were installed in valleys and foothills of Western Oregon. Three kinds of intermittent sand filters were installed, using design characteristics in Table 3-1, to biologically and physically treat septic tank effluent in 2 ft of medium sand similar to the sand that was used in construction of Wisconsin mounds (1, 2) except at least 25% was medium sand with a diameter of 0.25 to 0.50 mm with 25% or less finer than 0.25 mm. Effluent was applied from a pressure distribution system at an application rate not to exceed 1.23 gal/ft^2/day (3).

The first sand filter unit installed consisted of 2 cells contained within a concrete container (Figure 3-1). A 4 in. perforated underdrain

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was placed in the bottom of each cell and covered with about 8 in. of 3/4 in. washed gravel. Both cells were filled with 2 ft of medium sand (Table 3-2).

TABLE 3-1. DESIGN CHARACTERISTICS FOR INTERMITTENT SAND FILTERS[1]

Surface Area	366 ft^2
Filter Media Depth [1]	2 ft
Filter Media	Medium Sand 25% 0.25-0.5 <25%<0.25 mm
Filter Surface Buried by Soil Cover	Yes
Maximum Design Loading Rate	1.23 gal/ft^2/d
No. Times Effluent Applied to Filter Before Discharge	1
No. Doses Per Day	2 to 5
No. Gal Dosed/ft^2/Cycle	0.25-2.36 gal/ft^2/d
No. Gal Applied/Dose	100-250 gal
Dosing Controls	Volumetric; mercury float switches

[1] Characteristics shown are from a sand filter designed to process up to 450 gal septic tank effluent per day.

TABLE 3-2. SANDS USED IN OREGON INTERMITTENT FILTERS

	SAND CHARACTERISTICS		
SYSTEM	EFFECTIVE SIZE (mm)	UNIFORMITY COEFFICIENT	DEPTH (in.)
1 (Gilkey)	0.25	3.1	24
2 (Tolles)	0.20	2.1	24
3 (La Joie)	0.26	4.0	24
4 (McCurley)	0.28	3.2	24
5 (Grooms)	0.30	1.5	24
6 (Liesinger)	0.30	5.0	24
7 (Boettcher)	0.14	3.1	30

Perforated pressure distribution PVC piping was bedded in 3/4 to 2-1/2 in. washed gravel on top of the sand. Distribution piping was spaced 4 ft apart with 1/8 in. holes every 2 ft. Holes were oriented up. Pipe size varied from 3/4 to 2-1/2 in. diameter. The top of the filter was covered with 12 to 18 in. of silt loam, crowned, and seeded with grass to increase runoff, reduce infiltration, provide frost protection, and make them inaccessible to the public and animals. The other 2 sand filter units were similar except one consisted of a single cell in a concrete container (Figure 3-2) and the other was placed in an unlined trench excavated into saprolite (Figure 3-3).

Filter systems were designed so that septic tank effluent was pumped from a dosing tank to gravel filled beds or trenches through perforated distribution piping (4). Two-celled units used a duplex pump system that alternated application to each cell. The other 2 sand filter units used a single pump. The quantity of effluent applied with each dosing event ranged from 100 to 250 gal (Table 3-3). The design hydraulic loading rate was 1.23 gal/ft^2/d but actual hydraulic loading varied from 0.33 to 0.88 gal/ft^2/d (Table 3-3).

Pressure distribution systems were designed to provide approximately 5 ft of head at the remotest orifice of each lateral to prevent orifice clogging. Septic tank effluent made only one pass through the sand bed prior to discharge. Effluent processed by filtration through sand in a concrete container was collected in the 4 in. diameter underdrain and discharged into conventional disposal trenches 2 ft wide and 2 ft deep

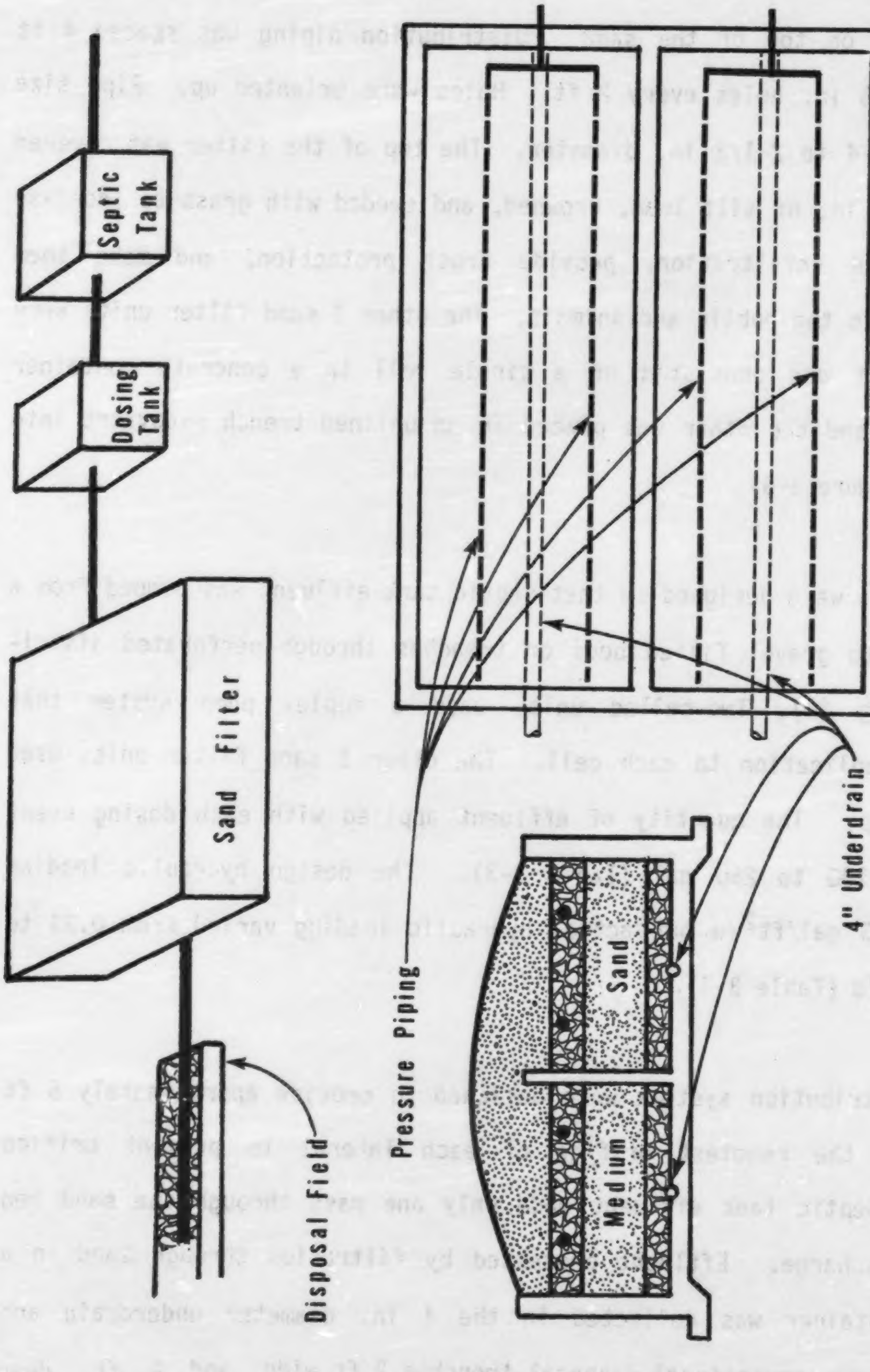
Septic Tank
Dosing Tank
Sand Filter
Disposal Field
Pressure Piping
4" Underdrain
Sand
Medium

FIGURE 3-1. DOUBLE CELLED INTERMITENT SAND FILTER

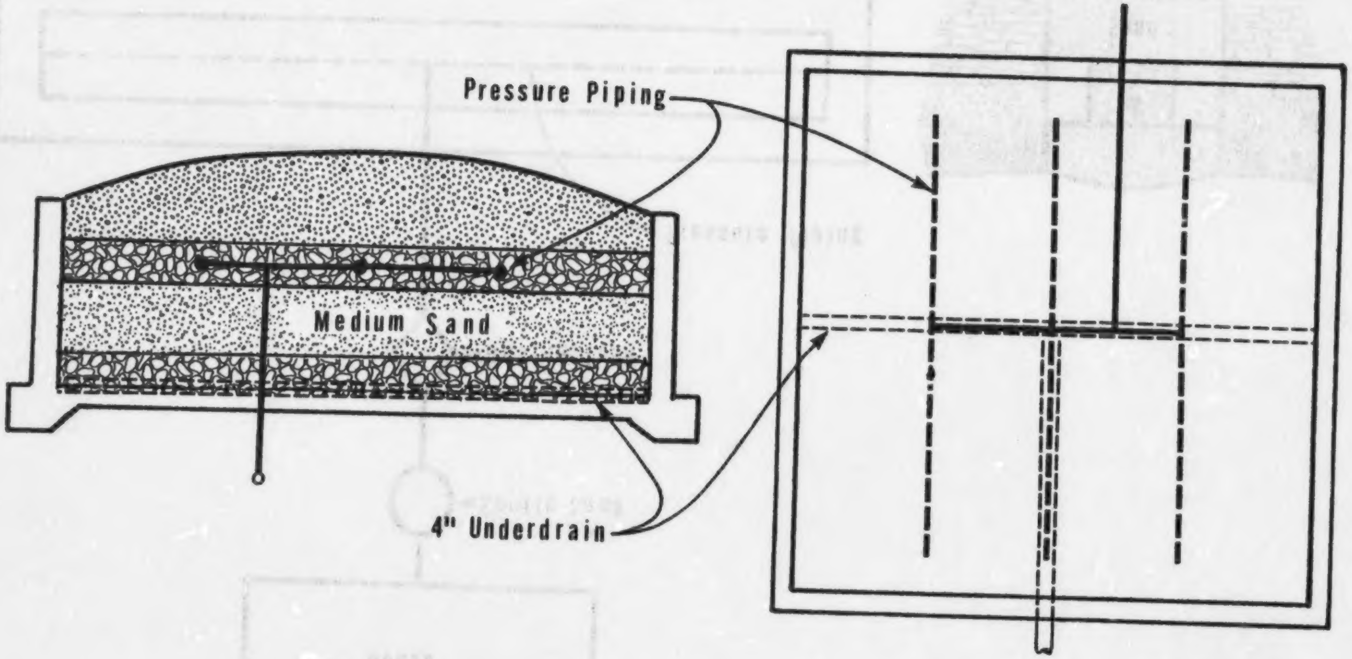
Pressure Piping
Medium Sand
4" Underdrain

FIGURE 3-2. SINGLE CELL INTERMITTENT SAND FILTER

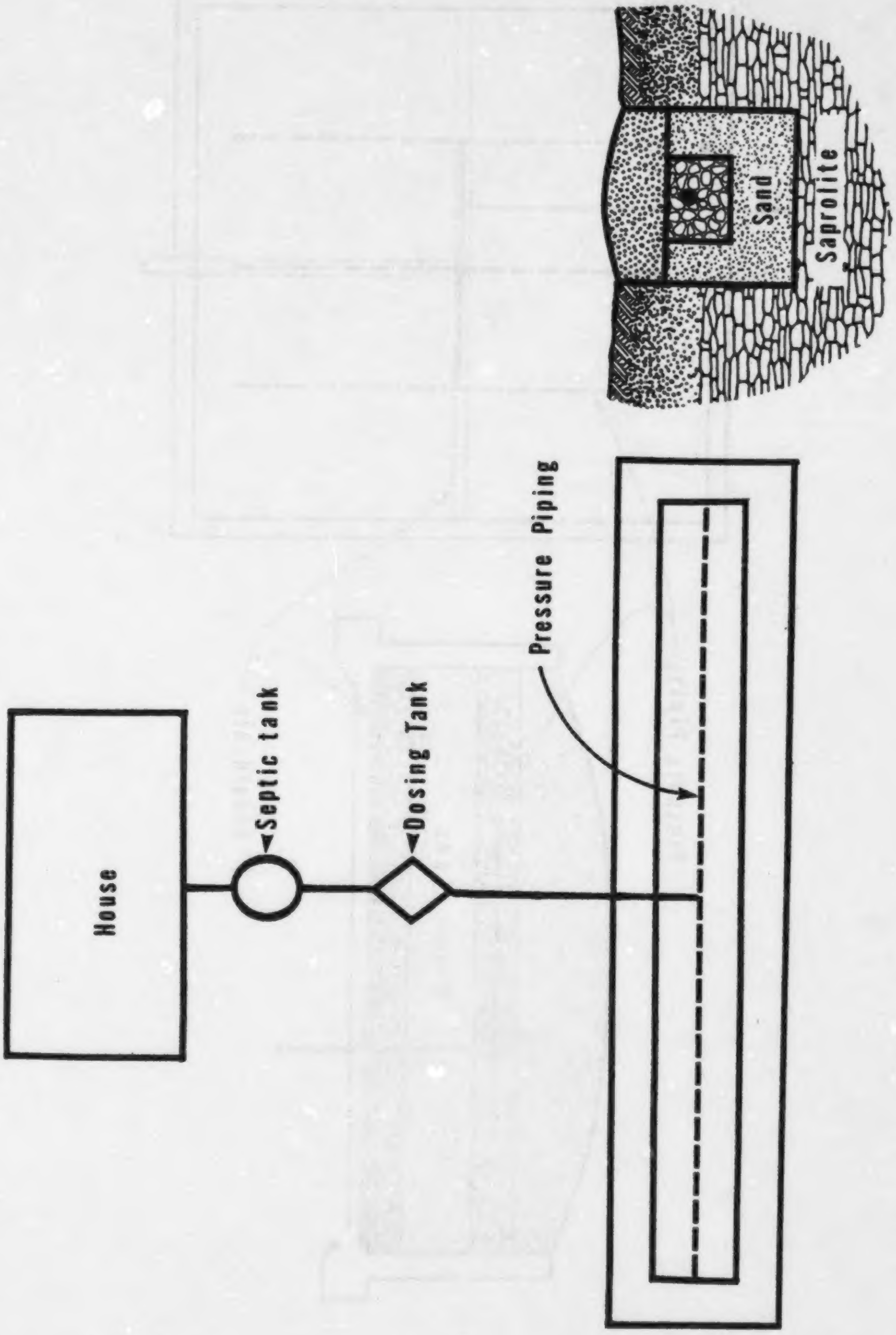
House
Septic tank
Dosing Tank
Pressure Piping
Sand
Saprolite

FIGURE 3-3. INTERMITTENT SAND FILTER PLACED IN SOILS SHALLOW TO SAPROLITE OR FRACTURED ROCK

TABLE 3-3 INTERMITTENT SAND FILTER HYDRAULIC LOADING CHARACTERISTICS

			HYDRAULIC LOADING			
SYSTEM	FILTER SURFACE AREA (ft^2)	DESIGN FLOW (gpd)	ACTUAL FLOW (gpd)	LOADING RATE (gal/ft^2/d)	DOSE VOLUME (gal/dose)	DOSING RATE (gal/ft^2/dose)
1 (Gilkey) 1,2	2-100	300	113	0.57	236; 112	2.36;1.12
2 (Tolles)	2-222	450	228	0.51	225	1.01
3 (LaJoie)	2-250	450	166	0.33	166	0.66
4 (McCurley)	400	450	191	0.48	110	0.28
5 (Grooms)	200	450	139	0.35	100	0.25
6 (Liesinger)	200	450	350	0.88	112	0.28
7 (Boettcher)	450	450	194	0.43	250	0.56

[1] The Gilkey, Tolles and LaJoie filters were divided into 2 cells and had total areas of 200, 444, and 500 ft^2 respectively.

[2] After several months operation, dose volume on the Gilkey filter was adjusted from 236 gal/dose to 112 gal/dose.

containing 4 in. diameter perforated plastic distribution piping bedded in 12 in. of gravel. Unlined filters had no underdrains. They discharged treated effluent directly into saprolite and fractured rock materials.

MONITORING

Filters were monitored to determine their mechanical operation and maintenance needs as well as their capacity to treat septic tank effluent. Effluent samples were collected and analyzed for BOD_5, SS, NO_3, NO_2, NH_3, total kjeldahl nitrogen (TKN), total nitrogen (TN), fecal coliform (FC), and total coliform (TC). Nitrate + nitrite-nitrogen was determined by the hydrazine reduction method, nitrite-nitrogen was determined through automated analysis by technicon, ammonia-nitrogen was determined by the phenate colorimeteric method, and total kjeldahl-nitrogen samples were digested in a technicon block digester and analyzed by the automated phenate method (5). Suspended solids were determined using U. S. EPA methods for chemical analyses of water and wastes (5). BOD_5 was determined by the Modified Winkler method and fecal and total coliforms were determined using the membrane filter method (6).

RESULTS AND DISCUSSION

OPERATION AND MAINTENANCE

Intermittent filters operated reliably throughout the 5-49 month period they were studied. No filter required maintenance.

Five filters (Table 3-4) were excavated to the sand-gravel interface after several months use to determine if a biological mat had formed. No odor, evidence of biomat formation, or effluent ponding was apparent.

TABLE 3-4. SAND CHARACTERISTICS, LOADING RATES, AND SELECTED SEPTIC TANK EFFLUENT CHARACTERISTICS OF 5 INTERMITTENT SAND FILTERS

		SAND CHARACTERISTICS			SELECTED SEPTIC TANK EFFLUENT CHARACTERISTICS[1]			
SYSTEM	MONTHS SYSTEM USED WHEN EXAMINED	EFFECTIVE SIZE (mm)	UNIFORMITY COEFFICIENT	AVERAGE LOADING RATE ($g/d/ft^2$)	BOD_5	SS	FC	TC
1 (Gilkey)	16	0.27	2.6	0.57	197 (11)[3]	38 (11)	1.1×10^5 (10)	1.8×10^6 (9)
3 (La Joie)[2]	29	0.26	4.0	0.33	--	--	--	--
4 (McCurley)	4	0.28	3.2	0.48	149 (8)	240 (8)	2.0×10^4 (10)	1.5×10^5 (8)
5 (Grooms)	17	0.30	1.5	0.70	188 (7)	79 (7)	7.0×10^4 (6)	7.7×10^4 (5)
6 (Boettcher)	52	0.14	3.1	0.43	222 (11)	193 (11)	---	---

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[1] Septic tank effluent BOD_5 and SS values expressed as arithmetic mean. Bacterial values expressed as geometric mean.

[2] No samples of septic tank effluent were analyzed at the La Joie system.

[3] Number of Samples.

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All pumps, dosing controls, and alarm systems functioned properly. However, equipment repair and replacement will be required periodically because of wear on submersible effluent pumps and the corrosive action of effluent on electrical controls. Septic tanks will also require regular periodic pumping to prevent overflow of solids into the filter sand.

SAND FILTER EFFLUENT QUALITY

Intermittent sand filters reduced BOD_5 more than 98% and SS more than 93% (Table 3-5). Suspended solids treatment was actually much better than these data indicate because sampling techniques contaminated effluent with sediment. Effluent samples at System 2 (Table 3-7) were collected from a drop structure following the sand filter. Most of these samples were taken when the filter was not discharging effluent. Consequently, grab samples were not taken from a flowing stream of effluent but from the drop structure. Effluent levels were low enough so that sediment was resuspended into the sample from the bottom of the drop structure during the sampling process. This resulted in SS concentrations as high as 200 mg/l. Five samples were collected when this sand filter was discharging effluent into the drop structure. The effluent was clear and the SS were less than 1 mg/l.

Effluent samples were collected from a "tee" placed in a depression in the line from System 4 (Table 3-7). A manually operated vacuum pump was used to obtain effluent samples. Effluent within the sampling structure was always clear before sampling, but sediment was easily detached and sucked into sampling containers during the sampling process. This caused mean

TABLE 3-5. A COMPARISON BETWEEN SINGLE FAMILY RESIDENTIAL SEPTIC TANK AND INTERMITTENT SAND FILTER EFFLUENTS[1]

EFFLUENT CHARACTERISTIC	SEPTIC[2] TANK EFFLUENT	INTERMITTENT SAND FILTER EFFLUENT	% CHANGE
BOD_5	217 (70)[3]	3.2 (84)	99
SS	146 (70)	9.6 (83)	93
NO_2	0.02 (57)	0.04 (50)	50
NO_3	0.4 (59)	29.1 (53)	99
NH_3	40.6 (60)	0.25 (52)	99
TKN	57.1 (57)	1.7 (50)	97
TN	57.5 (54)	30.3 (50)	47
FC	2.6×10^5 (56)	407 (93)	99 (3 logs)
TC	1.32×10^6 (46)	1.84×10^4 (39)	99 (2 logs)
Number Systems	8	7	

---

[1] BOD_5, SS and nitrogen expressed as mg/l; arithmetic mean. Fecal and total coliform expressed as org/100 ml; geometric mean.
[2] Arithmetic mean of 8 systems (Table 3-6).
[3] Number of samples.

SS concentrations considerably higher than they actually were in filtered effluent.

Suspended solids data from System 1 and System 3 provided a much better indication of filter treatment capacity. These systems were sampled from

TABLE 3-6. CHARACTERISTICS OF 8 OREGON SINGLE FAMILY RESIDENTIAL SEPTIC TANK EFFLUENTS

		SEPTIC TANK EFFLUENT CHARACTERISTICS[1]								
SYSTEM	AVE. FLOW (gpd)	BOD_5	SS	NO_3	NO_2	NH_3	TKN	TN	FC	TC
McCurley	191	149 (8)[2]	240 (8)	0.18 (9)	0.02 (9)	37.8 (9)	56.9 (9)	57.1 (9)	2.0×10^4 (10)	1.5×10^5 (8)
Gilkey	113	197 (11)	38 (11)	0.81 (10)	0.02 (10)	35 (10)	58.4 (10)	59.23 (10)	1.1×10^5 (10)	1.8×10^6 (9)
Grooms	139	188 (7)	79 (7)	0.04 (7)	0.02 (6)	35.5 (7)	45.6 (7)	45.66 (6)	7.0×10^4 (6)	7.7×10^5 (5)
Boettcher	194	222 (11)	193 (11)	-	-	-	-	-	-	-
Reber	176	378 (7)	276 (7)	0.18 (6)	0.02 (7)	53.3 (7)	83.6 (7)	83.8 (6)	5.4×10^5 (6)	2.1×10^6 (6)
McClaflin	161	125 (16)	91.7 (16)	0.56 (16)	0.02 (15)	36.1 (16)	51.26 (16)	51.84 (15)	8.0×10^4 (14)	9.9×10^5 (10)
Roberts	174	348 (7)	171 (7)	0.38 (8)	0.02 (7)	55.9 (8)	70.5 (7)	70.9 (7)	1.0×10^6 (8)	2.5×10^6 (6)
Anderson	---	322 (3)	203 (3)	0.24 (3)	0.02 (3)	32.56 (3)	47.2 (2)	47.46 (2)	8.1×10^4 (2)	1.3×10^6 (2)
Weighted Arithmetic Average	164 (7)	217 (70)	146 (70)	0.4 (59)	0.02 (57)	40.6 (60)	58.7 (58)	59.1 (55)	2.6×10^5 (56)	1.32×10^6 (46)

---

[1] BOD_5, SS, and nitrogen expressed as mg/l; arithmetic mean. Fecal and total coliform expressed as org/100 ml; geometric mean

[2] Number of samples.

drop structures similar to the one used for sampling System 2, but effluent liquid depths in these drop boxes were high enough to prevent significant sediment disturbance. Thus, little contamination of samples with suspended matter occurred.

TABLE 3-7. A COMPARISON BETWEEN INTERMITTENT SAND FILTER EFFLUENTS

SYSTEM	AVE. FLOW (gpd)	EFFLUENT CHARACTERISTICS								
		BOD_5[1]	SS	NO_3	NO_2	NH_3	TKN	TN	FC[2]	TC
1 (Gilkey)[3]	113	3 (21)[4]	2.2 (21)	40.96 (12)	0.04 (12)	0.2 (11)	0.6 (12)	41.6 (12)	537 (20)	4.0 x 10 (10)
2 (Tolles)	228	2.7 (21)	15.4 (21)	25.3 (14)	0.02 (14)	0.13 (13)	1.0 (13)	26.5 (13)	94 (28)	2.8×10^3 (6)
3 (LaJoie)	218	2.7 (30)	4 (30)	25.94 (11)	0.06 (11)	0.12 (11)	0.7 (11)	26.7 (11)	790 (30)	3.2×10^4 (9)
4 (McCurley)	191	6.4 (11)	28 (11)	28.8 (12)	0.08 (12)	0.7 (12)	1.6 (12)	31.2 (12)	30 (13)	784 (12)
Weighted Arithmetic Average	205 (7)	3.2 (84)	9.6 (83)	29.1 (53)	0.04 (50)	0.25 (52)	1.7 (50)	30.3 (50)	407 (93)	1.84×10^4 (39)

---

[1] BOD_5, suspended solids and nutrients expressed as mg/l; arithmetic mean.

[2] Total and fecal coliform bacteria expressed as org/100 ml; geometric mean.

[3] Mean and weighted arithmetic average values shown for the Gilkey system reflect effluent data collected at 2 dosing rates; 1.12 and 2.36 gal/ft^2/dose.

[4] Number of samples.

Sand filtration reduced total nitrogen by 47%. Ninety-six percent of the nitrogen in sand filter effluent was in an oxidized form compared to less than 1% in septic tank effluent (Tables 3-5 and 3-6). Results suggested septic tank effluent underwent 2 distinct stages of transformation. First, most organically bound nitrogen was rapidly broken down and oxidized along with ammonia as septic tank effluent passed through the first few inches of filter sands. Denitrification probably occurred in anaerobic microsites either in moisture films on sand grains and at points of sand grain contacts or in the zone of near saturation just above the sand-gravel interface or sand-saprolite interface.

Magdoff, Keeney, Bouma and Ziebell (7) suggested denitrification occurred within intermittent filter sands immediately above the sand-gravel interface. They reported accumulations of organic nitrogen in treatment sands just above gravel layers in their column studies.

Some denitrification may have resulted from the activities of facultative anaerobes which occupied oxygen deficient microsites in moisture films on and at sand grain contacts. Winneberger (8) suggested this mechanism was responsible for considerable denitrification.

Denitrification may also have occurred as a result of intermittent dosing and resting. Patrick and Reddy (9, 10) reported rapid breakdown of organic matter and the loss of fixed nitrogen by denitrification in soils which were subjected to cycles of anaerobic and aerobic conditions every 6-12 hours. Intermittent filters receiving 2-4 doses of septic tank effluent per day would have 6-12 hour aerobic resting intervals between dosing events.

Total nitrogen losses similar to those shown in intermittent filter effluents were also noted by mound investigators (11). However, filter nitrogen losses were higher than reductions reported by researchers who conducted gray water sand filter and soil column studies (12, 13).

Intermittent sand filters reduced fecal coliforms by 3 logs and total coliforms by 2 logs (Table 3-5). Similar coliform reductions were reported in effluents collected at the base of Wisconsin mound sands (11).

Fecal and total coliform counts were abnormally high in effluent from System 1 and System 3 (Table 3-7). System 3 was not loaded heavily and high coliform values appear to be anomalous. The loading rate was reduced from 2.36 gal/ft^2/dose to 1.12 gal/ft^2/dose in System 1 with corresponding reductions in total coliform from 90,000 to 18,400 and fecal coliform from 736 to 386 (Table 3-8). Bouma et al (14) observed a similar relationship between dosing rates and bacterial reduction. He concluded dosing rates exceeding 0.5 gal/ft^2 /dose were likely to cause saturated flow through medium sands, reducing the sands capacity to treat effluent.

TABLE 3-8. DOSING RATE VS. FECAL AND TOTAL COLIFORM REMOVAL PROVIDED BY INTERMITTENT SAND FILTERS

SYSTEM	DOSING RATE (gal/ft^2/dose)	SAND FILTER EFFLUENT[1] FECAL COLIFORM	TOTAL COLIFORM
1 (Gilkey)	2.36	736 (9)[2]	90,000 (9)
1 (Gilkey)	1.12	386 (11)	18,400 (8)
3 (LaJoie)	0.68	790 (30)	32,000 (9)

---

[1] Fecal and total coliform bacteria expressed as org/100 ml; geometric mean.

[2] Number of samples.

Comparable effluent samples were not collected at Systems 5, 6, and 7 because these are bottomless sand filters placed in an unlined trench excavated into saprolite (Figure 3-3).

DISPOSAL FIELD PERFORMANCE

Intermittent sand filter effluent from Systems 1, 2, 3, and 4 was discharged into 2 ft deep, 2 ft wide soil absorption trenches which contained 4 in. diameter perforated plastic distribution piping bedded in 12 in. washed gravel. Filtered effluent from Systems 5, 6, and 7 was discharged directly into saprolite or fractured basalt material immediately below filter sands.

Table 3-9 summarizes site conditions, design characteristics, and performance of trench soil absorption systems. Disposal trenches following Systems 1, 2, and 3 were placed in soils severely limited by shallowness to weathered rock or groundwater. In spite of these unfavorable conditions, disposal fields at these locations functioned satisfactorily. The disposal field for System 4 also functioned properly, but was installed in soils suitable for a standard soil absorption system.

During dry summer months, all effluent was absorbed by the first disposal trench following System 1 and System 2. However, during wet winter and spring months, the upper trench of these two systems intercepted a small amount of groundwater.

Effluent absorption patterns were less easy to determine at System 3 and System 4 because both filters discharged to equal distribution systems.

TABLE 3-9. A DESCRIPTION OF SITE CONDITIONS, SOIL ABSORPTION TRENCHES, AND TRENCH PERFORMANCE AT 4 INTERMITTENT SAND FILTER SYSTEM LOCATIONS

FEATURE DESCRIBED	SYSTEM			
	1 (GILKEY)	2 (TOLLES)	3 (LA JOIE)	4 (McCURLEY)
Soil Absorption System Site Limitation	14-19 in. soil over weathered granite	seasonal groundwater; mottling at 22 in.; dense fragipan at 22 in.	permanent groundwater; mottling at 9 in.	suspected permanent groundwater at 42 in.; no mottling evident; soils rapidly draining
Soil Texture at Absorption Trench Sidewall	14-19 in. clay loam over weathered granite	silt loam	sandy loam; slight salt concentration	sandy loam
Slope (%)	23	9	1	1
Average Drainfield Loading Rate (gpd)	113	228	166	191
Trench Type, Length,[1] and Sidewall Absorption Area (ft^2)	3-serial trenches 190 lin. ft (380)	4-serial trenches 440 lin. ft (880)	4-looped trenches 440 lin. ft (880)	5-equal distribution trenches 500 lin. ft (1000)
Average Daily Trench Sidewall Loading Rate (g/ft^2/d)	7.7	2.8	2.3	too rapid to determine
Average Percent System[2] Sidewall Used for Absorbing Effluent	3.5	9.4	8.3	too rapid to determine
Trench Installation Date	April 1977	August 1976	April 1977	June 1979
Observation Period	Dec. 1977-May 1980	Aug. 1976-Sept. 1980	April 1977-May 1980	July 1979-May 1981
Number of Observations	22	23	37	13

[1] Average trench depth was 24 in.; trenches contained 12 in. washed gravel and were gravity fed through 4 in. diameter perforated plastic distribution piping.

[2] Average percent sidewall used for absorbing sand filtered effluent was determined during dryer summer months at the La Joie and Tolles sites since trench sidewalls were often totally or partially inundated by groundwater during high precipitation months (November-April). Percent sidewall absorbing effluent was determined during high precipitation months at the Gilkey and McCurley sites.

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TABLE 3-10. THE RELATIONSHIP BETWEEN GROUNDWATER LEVELS AND WATER LEVELS OBSERVED IN DISPOSAL TRENCHES FOLLOWING THE LA JOIE SAND FILTER FROM MAY 1977 - MAY 1980

	OBSERVATION DATE	WATER ABOVE TRENCH BOTTOM (in.)[1,2]				DISTANCE FROM GROUNDWATER TO GROUND SURFACE IN MONITORING WELL (in.)[3]
		TRENCH 1	TRENCH 2	TRENCH 3	TRENCH 4	
MAY/OCTOBER	May 23, 1977	2	1	3	1	24
	June 6, 1977	2	2	4	2	25
	June 20, 1977	2	2	1	1	26
	July 11, 1977	2	2	3	1	26
	Aug. 8, 1977	2	2	2	1	26
	Oct. 4, 1977	3	2	2	1	24
	May 22, 1978	2	1	1	1	25
	June 12, 1978	dry	dry	dry	dry	dry
	July 18, 1978	1	1	1	1	26
	Aug. 14, 1978	2	1	1	1	dry
	Sept. 19, 1978	3	2	3	2	dry
	Aug. 29, 1979	dry	dry	dry	dry	dry
	May 20, 1980	4	2	2	1	---
NOVEMBER/APRIL	Nov. 1, 1977	4	2	2	2	dry
	Jan. 15, 1978	21	22	19	19	7
	Feb. 14, 1978	17	16	16	15	11
	Feb. 21, 1978	18	17	16	17	12
	March 14, 1978	18	18	14	14	15
	April 18, 1978	9	9	8	8	19
	Dec. 12, 1978	2	dry	1	dry	dry
	Jan. 23, 1978	14	12	12	12	14
	Feb. 27, 1979	7	6	7	7	18
	Jan. 17, 1980	7	7	7	7	16
	Feb. 24, 1980	7	7	6	6	---
	March 19, 1980	11	11	9	9	---
	April 1, 1980	13	12	12	12	---

[1] Trenches were 24 in. wide, and 24-27 in. deep. They contained 4 in. diameter perforated plastic piping bedded in 12 in. washed gravel. Gravel was backfilled with 12-15 in. topsoil.

[2] Slight variations in water depths were reported since measurements were not always made from the same position of monitoring wells each time monitoring took place and there was a small difference in surface elevation at well edges due to differential soil settlement.

[3] The outside monitoring well was a 4 in. diameter, 28 in. long plastic pipe. Ground surface elevation at the monitoring well was approximately 2 in. lower than average trench well elevations.

No effluent was observed in disposal trenches at System 4 but effluent was ponded in disposal trenches at System 3 during the wet winter and spring months when temporary groundwater inundated trenches (Table 3-10).

The treatment of septic tank effluent by sand filtration substantially reduced the rate of soil biomat formation. Although investigators disagree on which causative agent plays the most active role in biomat development, they all agree that BOD_5, SS, and fecal bacterial organisms, are the main factors responsible (15, 16, 17, 18, 19). The first disposal trench of System 3 was unearthed in February 1980, after 34 months use. No biomat had formed at the trench's bottom or sidewalls even though that trench's infiltrative surface had been partially or completely inundated by groundwater for several months each year (Table 3-10) and trenches had received an average of 218 gal of sand-filtered effluent per day (Table 3-7). When BOD_5, SS and fecal bacteria were reduced by intermittent sand filtration, soil absorbtion trench effluent infiltration rates remain high (Table 3-11). Examination of disposal trenches following these sand filters suggested that higher absorption rates occurred because biomats were absent. These rates were considerably higher than rates reported (20, 21, 22) for septic tank effluent (Table 3-11).

CONCLUSIONS

Intermittent sand filter beds required no maintenance during the monitoring period. All pumps, dosing controls, and alarm systems functioned properly but periodic maintenance and repair will no doubt be required.

TABLE 3-11. A COMPARISON BETWEEN INTERMITTENT SAND FILTER SOIL ABSORPTION TRENCH EFFLUENT ACCEPTANCE RATES AND RECOMMENDED SEPTIC TANK EFFLUENT LOADING RATES

SYSTEM	SOIL TEXTURE	FILTERED[1] EFFLUENT ACCEPTANCE RATE ($g/d/ft^2$)	RECOMMENDED SEPTIC TANK[2,3] EFFLUENT LOADING RATE ($g/d/ft^2$)	
			BOUMA	MACHMEIER
1 (Gilkey)	clay loam over weathered granite	7.7	0.72	0.5
2 (Tolles)	silt loam	2.8	0.72	0.5
3 (La Joie)	slightly salt cemented sandy loam	2.3	0.72	0.6
4 (McCurley)	sandy loam	too rapid to determine	0.72	0.6

[1] Based on sidewall area.

[2] Adapted from Table 7-2, EPA Design Manual; Onsite Wastewater Treatment and Disposal Systems.

[3] Based on bottom area; may be suitable estimates for sidewall infiltration rates.

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BOD_5, SS, and total nitrogen were reduced 98%, 93%, and 49% respectively. Results for suspended solids were abnormally high because of sampling difficulties. Denitrification probably occurred in anaerobic moisture films around sand grains and at points of sand grain contact and in the zone of near saturation just above the sand-gravel interface.

Total and fecal coliform organisms were about one log lower than they were in recirculating sand filter effluent. Total and fecal coliform reduction was directly related to hydraulic loading rate in one system.

All soil absorption systems functioned properly in spite of the fact that 3 were installed in soils severely limited by shallow depth to saprolite or high groundwater.

Biomat formation was not a problem and sand filter absorption rates were considerably higher than those commonly reported for septic tank effluent.

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CHAPTER 4

INTERMITTENT RECIRCULATING SAND FILTER SYSTEMS

Intermittent recirculating sand filters were installed and monitored under the same conditions as recirculating sand filters. Site limitations and affected acreages were discussed in Chapter 2. This chapter reports on intermittent-recirculating sand filter treatment of septic tank effluent prior to discharge into disposal trenches installed either in soils shallow to hardpans, claypans, saprolite, bedrock, and groundwater, or in soils with permeability rates either too rapid for adequate treatment or too slow for adequate disposal.

METHODS

SYSTEM DESIGN

Intermittent recirculating sand filter systems were installed at 8 single family residences (Systems 1-8) and a small sawmill-office building complex (System 9). Installations were made at valley and valley foothill locations between Western Oregon's Coast and Cascade mountain ranges.

The first 3 intermittent recirculating sand filter systems (Systems 6 to 8) were installed in Lane County under repair permits (1). They were installed to replace failing (surfacing) disposal fields. The original intermittent recirculating sand filter was designed by Gary Colwell and Craig Starr, 2 Lane County Department of Environmental Management Staff Engineers (2). The filter was later patented by a private Oregon investment company (3).

TABLE 4-1. DESIGN CRITERIA FOR INTERMITTENT RECIRCULATING SAND FILTERS[1]

Filter Media	medium sand 25% 0.25-0.50 mm <25%<0.25 mm
Septic Tank Effluent Absorption System	
Distribution Technique	2-gravity fed, 10 ft long, 12 in. wide 18 in. deep absorption trenches containing 4 in. perforated distribution piping bed in a 12 in. layer of washed gravel
Absorption Trench[2] Infiltrative Surface Area	64 ft^2
Depth Filter Sand Below STE Absorption Trenches	24 in.
Recirculation System	
Distribution Technique	4-quarter circle pattern shrub spray heads located at filter corners
Infiltrative Surface Area	144 ft^2
Depth Sand Below Infiltrative Surface	42 in.
Infiltrative Surface Open to Atmosphere	Yes
Design Loading Rate	3.125 gal/ft^2 infiltrative surface/d
Dose Volume	15-25 gal
Dosing Rate	0.1 - 0.17 gal/ft^2/dose
Dosing Frequency	48 doses/day
Times Effluent Recirculated Before Discharge	3-4 min
Dosing Controls	percentage timer and free floating mercury switches

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[1] Characteristics shown are for a residential sand filter designed to process up to 450 gal wastewater per day.

[2] Infiltrative surface includes trench bottom, sidewall, and end areas.

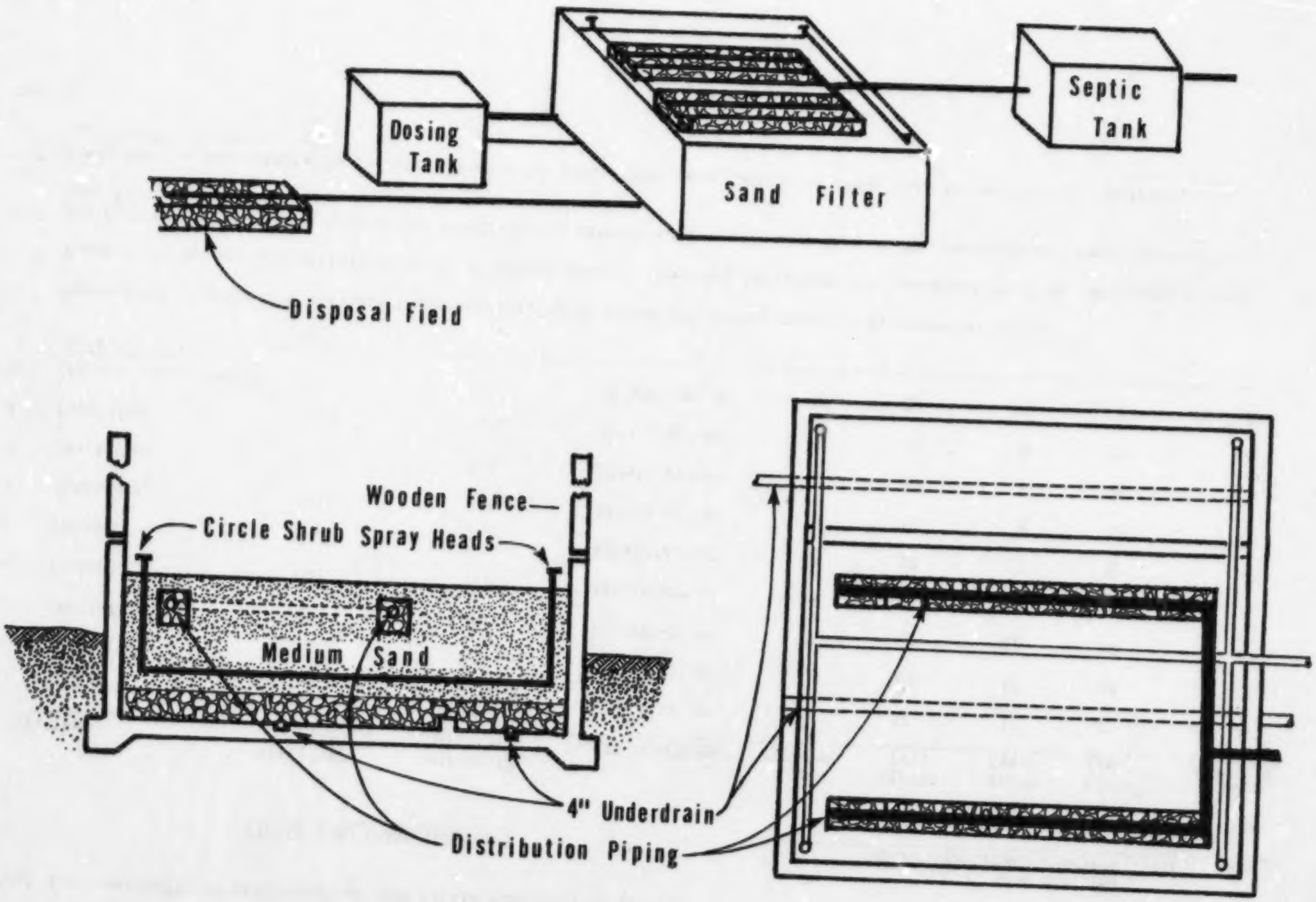
Septic Tank
Sand Filter
Dosing Tank
Disposal Field
Wooden Fence
Circle Shrub Spray Heads
Medium Sand
4" Underdrain
Distribution Piping

FIGURE 4-1. INTERMITTENT RECIRCULATING SAND FILTER

TABLE 4-2. INTERMITTENT RECIRCULATING SAND FILTER CONSTRUCTION DETAILS

	FILTER SAND CHARACTERISTICS			SEPTIC TANK EFFLUENT ABSORPTION TRENCH CHARACTERISTICS				
SYSTEM	EFFECTIVE SIZE (mm)	UNIFORMITY COEFFICIENT	FILTER DIMENSION[1]	NO. TRENCHES	LENGTH (ft)	WIDTH (in.)	DEPTH[2] (in.)	NO.[3] SPRAYHEADS
1 (Turner)	0.2	2.5	14'x14'x3'-6"	3	12	12	18	4
2 (Roberts)	0.27	2.0	12'x12'x3'-6"	2	10	12	18	4
3 (McClaflin)	0.3	3.2	12'x12'x3'-6"	2	10	12	18	4
4 (Reber)	0.3	1.5	14'x14'x3'-6"	4	12	12	18	4
5 (Grooms)	0.3	1.5	12'x12'x3'-6"	2	10	12	18	4
6 (Chester)	0.28	3.6	12'x12'x3'-6"	2	10	8	16	4
7 (Matteson)	0.28	3.6	12'x12'x3'-6"	2	10	8	16	4
8 (Steidley)	0.28	2.2	12'x12'x3'-6"	2	10	8	16	4
9 (International Paper[4] Corporation)	---	---	26'x26'x4'-10"	2	24	54	16	9

[1] Measurements represented indicate the dimension inside filter containers occupied by treatment media.

[2] Trenches in Systems 1-5 contained 12 in. of washed gravel. Trenches in Systems 6-9 contained 10-12 in. of washed gravel.

[3] One full circle, 4-quarter circle and 4-half circle pattern spray heads were used at the International Paper Corporation sand filter.

[4] Sands used in the International Paper Corporation sand filter were similar to those used in the Chester, Matteson, and Steidley filters.

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Design criteria for a typical residential intermittent recirculating sand filter are shown in Table 4-1. Septic tank effluent entered filters through shallow, gravity fed subsurface infiltration trenches bedded in filter sands (Figure 4-1).* Effluent passed through 24 in. of filter sand into a 4 in. perforated plastic underdrain pipe bedded in a layer of washed gravel, and drained to the recirculation tank. Filter system treatment sand and trench characteristics are shown in Table 4-2. Filters serving residences with 3 or fewer bedrooms contained 2 infiltration trenches. Systems 2 and 4, had 3 and 4 trenches respectively because they were connected to larger homes with higher design flows.

Each half hour, 15 to 25 gal of filter effluent were pumped from the recirculation tank to the open filter surface via 4 quarter-pattern shrub spray heads located in filter corners.** Recirculation cycles lasted 5 minutes.

A 25 minute resting interval followed each recirculation event. Recirculation cycles were regulated by time clock controls synchronized with overriding high-level "on", low-level "off" volumetric controls (free floating mercury switches). Tanks were also equipped with a mercury float actuated high level water alarm. Once recirculated effluent infiltrated through the open filter surface, it passed downward through at least 42 in. of treatment sand and 12 in. of underdrain gravel. A 6 in. high concrete partition extended from the bottom of Filters 1, 3, 4, and 5 so 3/4 of the effluent returned to the recirculation tank for additional application to the filter. System 9 was similarly divided so that 2/3 of the effluent returned to the recirculation tank. A second underdrain on the opposite side of the partition drained filtrate to soil absorption trenches. Systems 6, 7, and 8 had a single underdrain which conveyed all filter effluent back to the recirculation tank. An outlet at the end of the tank regulated the volume of effluent discharged to soil absorption trenches. The amount of effluent discharged during a particular time period was equivalent to the quantity of wastewater and any incident precipitation that fell onto the filter during that time interval.

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* Septic tanks serving System 9 were at a lower elevation than the sand filter so septic tank effluent was pumped from a surge tank to filter infiltration trenches. Dosing events were regulated by free floating mercury switches.

** System 9 used 9 shrub spray heads. Spray patterns are indicated in Table 4-2.

All intermittent recirculating sand filters except System 9 and System 3 were enclosed in 4 ft high wood frame fences to prevent the entry of children and animals and help confine spray to the filter area. System 9 was in a roofed, wood-frame structure, and a fence was never constructed around System 3.

MONITORING

Filters were monitored to determine their mechanical operation and maintenance needs as well as their capacity to treat septic-tank effluent. Effluent samples were collected and analyzed for BOD_5, SS, NO_2, NO_3, NH_3, total kjeldahl nitrogen (TKN), total nitrogen (TN), fecal coliform (FC), and total coliform (TC). Nitrate + nitrite-nitrogen was determined by the hydrazine reduction method, nitrite-nitrogen was determined through automated analysis by technicon, ammonia-nitrogen was determined by the phenate colorimeteric method, and total kjeldahl-nitrogen samples were digested in a technicon block digester and analyzed by the automated phenate method (4). Suspended solids were determined using U. S. EPA methods for chemical analyses of water and wastes (4). BOD_5 was determined by the Modified Winkler method and fecal and total coliforms were determined using the membrane filter method (5).

RESULTS AND DISCUSSION

HYDRAULIC LOADING

Residential filters were loaded at an average rate of 1.12 gal/ft^2/d, 36% of their design rate (Table 4-3). The industrial filter received an average of 4.44 gal/ft^2/d, 1.42 times its design loading rate. That filter occasionally received loads as high as 10,000 gpd (data not shown), 4.73 times its peak design flow (3).

SAND FILTER EFFLUENT QUALITY

Sand filtration decreased BOD_5 and SS 98%, total nitrogen 39%, and fecal and total coliforms 4 logs (Table 4-4). In residential filter effluent, 98.6% of the nitrogen was in a nitrate form compared to 1% in septic tank effluent.

Nitrogen content in effluent from System 7 was much higher than nitrogen levels in other residential filter effluents. Wastewater received by System 7 was produced by a limited number of fixtures (toilet, shower, bathroom lavatory, and kitchen sink) used by an elderly woman visited occasionally by two sons.

Shortly after seasonal rainfall started, considerable groundwater infiltrated into the septic tank or sewer lines preceding System 8. This diluted septic tank effluent and interfered with filter treatment.

For the reasons cited, filter nitrate data from System 7 and effluent data for all parameters from System 8 were excluded from weighted residential filter averages indicated in Tables 4-4 and 4-6.

TABLE 4-3. AVERAGE DAILY LOADING RATES FOR 6 INTERMITTENT RECIRCULATING SAND FILTERS

SYSTEM	EXPOSED FILTER SURFACE AREA (ft^2)	AVERAGE DAILY FLOW (g)	LOADING RATE ($g/ft^2/d$)
1 (Turner)	196	278	1.42
2 (Roberts)	144	174	1.20
3 (McClaflin)	144	161	1.12
4 (Reber)	196	176	0.90
5 (Grooms)	144	139	0.97
6 (Chester)[1]	144	---	---
7 (Matteson)	144	---	---
8 (Steidley)	144	---	---
9 (International Paper Corporation)	676	3,000	4.44

[1] No flow data was collected from Systems 6, 7, and 8 (Chester, Matteson, and Steidley). Lane County repair permit provisions did not require flow measuring devices.

Total nitrogen in residential sand filter effluent fluctuated 11% seasonally (Table 4-7). Total nitrogen concentrations averaged 32.4 mg/l in cool, moist months and 36.4 mg/l during warm, dry months. Similar nitrate nitrogen fluctuations (31.8 mg/l November to April and 35.4 mg/l May through October) were observed during wet and dry seasons.

TABLE 4-4. A COMPARISON BETWEEN SINGLE FAMILY RESIDENTIAL SEPTIC TANK AND INTERMITTENT RECIRCULATING SAND FILTER EFFLUENTS[1]

EFFLUENT CHARACTERISTIC	SEPTIC[2] TANK EFFLUENT	INTERMITTENT[3] RECIRCULATING SAND FILTER EFFLUENT	% CHANGE
BOD_5	217 (70)[4]	3.4 (56)	98
SS	146 (70)	3.4 (100)	98
NO_2	0.02 (57)	0.06 (38)	67
NO_3	0.4 (59)	33.8 (45)	99
NH_3	40.6 (60)	0.36 (36)	99
TKN	57.1 (57)	1.1 (35)	98
TN	57.5 (54)	34.9 (45)	39
FC	2.6×10^5 (56)	54.0 (112)	99 (4 logs)
TC	1.32×10^5 (46)	628 (94)	99 (4 logs)

---

[1] BOD_5, SS and nitrogen expressed as mg/l; arithmetic mean. Fecal and total coliform expressed as org/100 ml; geometric mean.

[2] Arithmetic mean of 8 systems (Table 4-5).

[3] Arithmetic mean of 7 systems (Table 4-6).

[4] Number of samples.

TABLE 4-5. CHARACTERISTICS OF 8 OREGON SINGLE FAMILY RESIDENTIAL SEPTIC TANK EFFLUENTS[1]

SYSTEM	AVE. FLOW (gpd)	SEPTIC TANK EFFLUENT CHARACTERISTICS								
		BOD_5	SS	NO_3	NO_2	NH_3	TKN	TN	FC	TC
2 (Roberts)	174	348 (7)[2]	171 (7)	0.38 (8)	0.02 (7)	55.9 (8)	70.5 (7)	70.9 (7)	1.0×10^6 (8)	2.5×10^6 (6)
3 (McClaflin)	161	125 (16)	91.7 (16)	0.56 (16)	0.02 (15)	36.1 (16)	51.3 (16)	51.8 (15)	8.0×10^4 (14)	9.9×10^5 (10)
4 (Reber)	176	378 (7)	276 (7)	0.16 (6)	0.03 (7)	53.3 (7)	71.8 (6)	71.9 (5)	5.4×10^5 (6)	2.1×10^6 (6)
5 (Grooms)	139	188 (7)	79 (7)	0.04 (7)	0.02 (6)	35.5 (7)	45.6 (7)	45.67 (6)	7.0×10^4 (6)	7.7×10^5 (5)
McCurley	191	149 (8)	240 (8)	0.18 (9)	0.02 (9)	37.8 (9)	56.9 (9)	57.1 (9)	2.0×10^4 (10)	1.5×10^5 (8)
Gilkey	113	197 (11)	38 (11)	0.81 (10)	0.02 (10)	35 (10)	58.4 (10)	59.2 (10)	1.1×10^5 (10)	1.8×10^6 (9)
Boettcher	194	222 (11)	193 (11)	-	-	-	-	-	-	-
Anderson	---	322 (3)	203 (3)	0.24 (3)	0.02 (3)	32.56 (3)	47.2 (2)	47.5 (2)	8.1×10^4 (2)	1.3×10^6 (2)
Weighted Arithmetic Average	164 (7)	217 (70)	146 (70)	0.4 (59)	0.02 (57)	40.6 (60)	57.1 (51)	57.5 (54)	2.6×10^5 (56)	1.32×10^6 (46)

---

[1] BOD_5, SS and nitrogen expressed as mg/l; arithmetic mean.
Fecal and total coliform expressed as org/100 ml; geometric mean.

[2] Number of samples.

Though lower, seasonal fluctuations in total nitrogen and nitrate-nitrogen found in intermittent recirculating sand filter effluents were similar to variations noted in recirculating sand filter effluents (Chapter 2).

TABLE 4-6. A COMPARISON BETWEEN INTERMITTENT RECIRCULATING SAND FILTER EFFLUENTS

SYSTEM	AVE. FLOW (gpd)	SAND FILTER EFFLUENT CHARACTERISTICS[1,2]								
		BOD_5	SS	NO_2	NO_3[2]	NH_3	TKN	TN	FC	TC
1 (Turner)	278	3.0 (7)[3]	3.1 (7)	0.09 (5)	23.2 (5)	0.47 (5)	1.2 (4)	24.5 (5)	54 (6)	1,833 (2)
2 (Roberts)	174	3.8 (8)	3.8 (8)	0.06 (8)	38.4 (8)	0.6 (8)	1.1 (8)	39.6 (8)	51 (10)	858 (8)
3 (McClaflin)	161	2.8 (13)	5.1 (7)	0.05 (14)	33.2 (14)	0.22 (14)	0.8 (14)	34.1 (14)	113 (12)	572 (7)
4 (Reber)	176	3.3 (3)	1.5 (2)	0.06 (5)	32.4 (2)	0.44 (4)	1.7 (4)	34.2 (2)	41 (5)	950 (5)
5 (Grooms)	139	4.0 (4)	5.0 (2)	0.04 (4)	24.4 (2)	0.21 (4)	1.5 (4)	26 (2)	17 (4)	1,046 (4)
6 (Chester)	---	3.5 (11)	3.6 (57)	0.06 (2)	37.1 (14)	0.18 (1)	0.7 (1)	37.9 (14)	54 (55)	523 (54)
7 (Matteson)	---	3.6 (10)	2.0 (17)	0.05 (9)	82.0 (19)	0.23 (7)	0.5 (8)	82.6 (19)	29 (20)	520 (14)
8 (Steidley)	---	28.9 (20)	21.5 (45)	0.14 (19)	6.5 (36)	5.5 (20)	12.5 (19)	19.1 (19)	705 (46)	3,100 (37)
Weighted Arithmetic Average (Excludes System 8)	186 (5)	3.4 (56)	3.4 (100)	0.06 (38)	33.8 (45)	0.36 (36)	1.1 (35)	34.9 (45)	54 (112)	628 (94)
Weighted Arithmetic Average (Includes System 8)	186 (5)	10.1 (76)	9.0 (145)	0.09 (57)	21.7 (81)	2.2 (56)	5.1 (54)	30.2 (64)	244 (158)	1,326 (131)

[1] BOD_5, SS, and nitrogen expressed as mg/l; arithmetic mean. Fecal and total coliform expressed as org/100 ml; geometric mean.

[2] Weighted average excludes nitrogen contents from System 7.

[3] Number of samples.

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TABLE 4-7. A SEASONAL COMPARISON OF NITROGEN CONCENTRATIONS IN RESIDENTIAL INTERMITTENT RECIRCULATING SAND FILTER EFFLUENTS[1]

SYSTEM	NOVEMBER - APRIL					MAY - OCTOBER				
	NO_2	NO_3	NH_3	TKN	TN	NO_2	NO_3	NH_3	TKN	TN
1 (Turner)	0.07 (1)[2]	18.8 (1)	0.9 (1)	1.4 (1)	19.3 (1)	0.09 (4)	24.3 (4)	0.36 (4)	1.2 (4)	25.6 (4)
2 (Roberts)	0.04 (4)	32.6 (7)	0.76 (5)	0.55 (5)	33.2 (7)	0.02 (2)	48.6 (2)	0.15 (2)	(0.7) (2)	49.3 (2)
3 (McClaflin)	0.06 (8)	32.4 (9)	0.19 (9)	0.63 (9)	33.1 (9)	0.02 (3)	40.5 (3)	0.3 (3)	0.7 (3)	41.2 (3)
4 (Reber)	0.05 (2)	32.3 (4)	0.14 (2)	0.44 (4)	32.8 (4)	---	---	---	---	---
5 (Grooms)	---	---	---	---	---	0.04 (2)	24.4 (2)	0.23 (3)	1.0 (3)	25.7 (3)
6 (Chester)	---	---	---	---	---	0.06 (2)	37.1 (14)	0.18 (1)	0.7 (1)	37.9 (14)
7 (Matteson)	0.04 (3)	34.8 (9)	0.1 (3)	0.63 (3)	35.5 (3)	0.06 (6)	123.4 (10)	0.33 (4)	48 (5)	124 (4)
8 (Steidley)	0.02 (12)	1.7 (13)	5.3 (12)	12.5 (12)	14.2 (12)	0.02 (6)	11.64 (12)	5.64 (6)	9.7 (6)	21.4 (6)
Weighted Arithmetic Average (Excludes Systems 7 and 8)	0.05 (15)	31.8 (21)	0.4 (17)	0.6 (19)	32.4 (21)	0.05 (13)	35.4 (25)	0.27 (13)	0.92 (14)	36.4 (14)

[1] Nitrogen values expressed as mg/l; arithmetic means.

[2] Number of samples.

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As was the case with recirculating sand filter effluents, organically bound and free ammonia nitrogen in intermittent recirculating sand filter effluent showed little seasonal variation. This suggested dilution by precipitation, organic nitrogen accumulation during cool moist months, and mineralization during warm dry months, or denitrification in anaerobic microsites during moist months were responsible for annual fluctuations in total nitrogen and nitrate-nitrogen.

Some denitrification of septic tank effluent probably occurred at the gravel-sand interface of the filter infiltration trenches once a biological mat (biomat) formed and effluent ponding within trenches occurred. Denitrification also likely took place in the saturated zone where treatment sand contacted underdrain gravel.

Although data do not support the hypothesis, a small amount of nitrogen loss may have occurred due to ammonia volatilization during warm, dry months.

Comparison of sand filter effluent quality data (Tables 4-8, 4-9, and 4-10) showed 3 distinct levels of treatment which corresponded to the degree of biomat formation and ponding.

TABLE 4-8. THE RELATIONSHIP BETWEEN RESIDENTIAL INTERMITTENT RECIRCULATING SAND FILTER TREATMENT AND FILTER ABSORPTION TRENCH MATTING; PRE-MAT DEVELOPMENT PERIOD[1]

SYSTEM	CHARACTERISTIC						
	BOD_5	SS	$NO_2 + NO_3$	NH_3	TKN	FC	TC
1 (Turner)	2.5 (2)[2]	5.5 (12)	---	---	---	---	---
2 (Roberts)	5.5 (2)	9.0 (2)	1.2 (2)	2.5 (2)	3.9 (2)	1,470 (2)	16,000 (2)
3 (McClaflin)	---	---	---	---	---	---	---
4 (Reber)	---	---	---	---	---	---	---
5 (Grooms)	---	---	---	---	---	---	---
6 (Chester)[3]	4.3 (7)	9.1 (10)	15.6 (8)	4.1 (8)	6.3 (8)	569 (7)	1,461 (6)
7 (Matteson)[4]	3.6 (10)	2.1 (17)	81.5 (19)	0.23 (7)	0.6 (8)	28 (19)	1,590 (16)
8 (Steidley)	---	4.8 (10)	---	---	---	479 (11)	3,022 (11)
Weighted Arithmetic Average	3.9 (21)	5.0 (41)	12.7 (10)	3.8 (10)	5.4 (10)	326 (39)	2,841 (35)

---

[1] Table includes data from the period immediately following filter system startup to the point when a visible mat formed at the base of filter septic tank effluent absorption trenches.

[2] Number of samples.

[3] Data shown is for a 2 month interval following the diversion of septic tank effluent into a previously unused filter absorption trench.

[4] Weighted average excludes nitrogen species from System 7 since only a toilet, bathroom lavatory, shower and kitchen sink were attached to the system, causing nitrogen content to be much higher than other residences studied. Although no visible mat appeared at the bottom of System 7's filter absorption trenches during the period the system was monitored (probably as a result of the limited hydraulic loading, low BOD_5 and low suspended solids applied to the filter) there was a definite increase in nitrogen species with time indicating some nitrogen had been assimilated as biomass after the filter was placed into operation.

TABLE 4-9. THE RELATIONSHIP BETWEEN RESIDENTIAL INTERMITTENT RECIRCULATING SAND FILTER TREATMENT AND FILTER ABSORPTION TRENCH MATTING; AFTER A MAT FORMED[1]

	CHARACTERISTIC						
SYSTEM	BOD_5	SS	$NO_2 + NO_3$	NH_3	TKN	FC	TC
1 (Turner)	3.0 (7)[2]	3.1 (7)	23.2 (5)	0.47 (5)	1.2 (5)	54 (6)	1,833 (2)
2 (Roberts)	3.8 (8)	3.8 (8)	46.5 (7)	0.60 (8)	1.1 (8)	22 (7)	322 (6)
3 (McClaflin)	2.8 (13)	5.1 (7)	33.2 (14)	0.22 (14)	0.8 (14)	113 (12)	572 (7)
4 (Reber)	3.3 (3)	1.5 (2)	32.4 (2)	0.44 (4)	1.7 (4)	41 (5)	600 (5)
5 (Grooms)	4.0 (4)	5.0 (2)	24.4 (2)	0.21 (4)	1.5 (4)	17 (4)	1,046 (4)
6 (Chester)	2.0 (4)	3.3 (42)	37.1 (14)	0.18 (1)	0.7 (1)	40 (42)	472 (42)
7 (Matteson)	---	---	---	---	---	---	---
8 (Steidley)	---	3.0 (9)	24.5 (9)	---	---	58 (9)	402 (9)
Weighted Arithmetic Average	3.1 (39)	3.5 (77)	33.2 (53)	0.36 (36)	1.1 (36)	51 (85)	536 (75)

[1] Data shown is from the period when trench matting first appeared to the point just before trenches became completely clogged by a biomat.

[2] Number of samples.

TABLE 4-10. THE RELATIONSHIP BETWEEN RESIDENTIAL INTERMITTENT RECIRCULATING SAND FILTER TREATMENT AND FILTER ABSORPTION TRENCH MATTING; AFTER TRENCH CLOGGING AND EFFLUENT PONDING ABOVE THE FILTER SURFACE[1]

	CHARACTERISTIC						
SYSTEM	BOD_5	SS	$NO_2 + NO_3$	NH_3	TKN	FC	TC
1 (Turner)	47.1 (6)[2]	61.8 (6)	0.26 (7)	16.4 (7)	33.4 (7)	10,895 (9)	---
2 (Roberts)	---	---	---	---	---	---	---
3 (McClaflin)	---	---	---	---	---	---	---
4 (Reber)	---	---	---	---	---	---	---
5 (Grooms)	---	---	---	---	---	---	---
6 (Chester)	---	---	---	---	---	---	---
7 (Matteson)	---	---	---	---	---	---	---
8 (Steidley)	28.9 (20)	33 (25)	0.27 (20)	55 (20)	12.5 (19)	1,802 (26)	1.7×10^4 (9)

[1] Data shown is from the period after trenches had become completely clogged by a biomat and vented to the filter surface.

[2] Number of samples.

The first few weeks following filter use (early mat development), were accompanied by a steady decline in total coliform, fecal coliform, ammonia nitrogen and total kjeldahl nitrogen. During this period, fecal and total coliform were reduced an average of 3 logs. Data suggested nitrogen accumulated as biomass at the gravel-sand interface of filter septic tank effluent infiltration trenches (Table 4-8). Work by Magdoff et al., (6) support the idea that nitrogen accumulated as biomass. In their sand column studies, they noted accumulations of nitrogen in the upper few centimeters of sand adjacent to the sand-gravel interface.

After 60 to 90 days (depending upon hydraulic loading and influent waste strength), a visible biomat formed at the base of septic tank effluent infiltration trenches. When matting occurred, filter treatment increased (Table 4-9). Further reductions in BOD_5, SS, ammonia nitrogen, and total kjeldahl nitrogen were evident. Nitrate and total nitrogen more than doubled, and fecal and total indicators decreased an additional log. The maximum level of treatment (data not shown) occurred just before infiltration trench sidewalls became completely clogged with a biomat.

The biological matting of septic tank effluent infiltration trenches was responsible for the higher level of treatment provided by the filters. A similar relationship between mat formation and high levels of bacterial removal were reported by Ziebell et al., (7) in their Plainfield loamy sand column studies.

With the exception of Systems 3 and 7, infiltrative surfaces of all filter septic tank effluent infiltration trenches eventually became clogged with a biomat. Where filter use continued under clogged conditions (Systems 1 and 8), septic tank effluent vented from infiltration trenches and ponded on the filter surface. When this occurred there was a sharp decline in filter treatment (Table 4-10). BOD_5 and SS increased sharply. Less than 2% of the nitrogen in filter effluent was nitrified, and fecal coliform levels rose 3 logs.

Since treatment sands remained moist but unsaturated at this time, ponded effluent probably short circuited to the underdrain by channelized flow along the filter container wall. This theory was supported by the fact that there was little difference in the total nitrogen content of effluent ponded over filters and that which had passed through the filters (data not shown); indicating little denitrification had occurred.

Filter effluent quality produced under ponded conditions correlated well with work done by other investigators. Russell (8) determined a high quantity of nitrate ion must be available if denitrification is to occur. Studies by Bouma, et al. (9) demonstrated greater removal of chemical impurities from septic tank effluents took place under unsaturated aerobic conditions than under saturated anaerobic conditions, and laboratory column findings by McCoy and Ziebell (10) showed the greatest level of bacterial removal took place under conditions of unsaturated flow.

Although the majority of the nitrogen (98%) in effluent from System 8 was in a reduced form once filter ponding occurred, the influence of groundwater infiltration was quite apparent (Table 4-10). The total nitrogen content in effluent from System 8 was 2.6 times lower than that found in effluent from System 1.

INDUSTRIAL FILTER EFFLUENT TREATMENT

The industrial intermittent recirculating sand filter (System 9) provided a high level of effluent treatment. The filter reduced BOD_5 and SS 90% and 93% respectively and lowered coliforms 2 logs (Table 4-11).

Since effluent sampling from System 9 was limited to its first 9 months operation, data were not sufficient to determine if nitrate-nitrogen and total nitrogen contents fluctuated seasonally the way they did in residential filter effluents.

Hydraulic loading had considerable influence on filter nitrification. Effluent data from System 9 (loaded at 4.44 $gal/ft^2/d$) indicated quasi-saturated conditions in filter sands limited the degree of nitrification. Forty-six and three-tenths percent of the nitrogen in System 9's effluent was oxidized. By comparison, 96.8% of the nitrogen in residential sand filter effluents (loaded at an average of 1.12 $gal/ft^2/d$) was in an oxidized form.

Hydraulic loading also influenced degree of denitrification provided by filters. Considerably greater denitrification (58%) took place in System 9, even though there was incomplete nitrification of ammonia, since sands in that filter were more saturated. Most authorities agree denitrification is encouraged by poor aeration and the availability of large amounts of nitrate ion (11).

TABLE 4-11. A COMPARISON BETWEEN INDUSTRIAL SEPTIC TANK AND INTERMITTENT RECIRCULATING SAND FILTER EFFLUENTS (SYSTEM 9)[1,2]

EFFLUENT[3,4] CHARACTERISTIC	SEPTIC TANK EFFLUENT	INTERMITTENT RECIRCULATING SAND FILTER EFFLUENT	% CHANGE
BOD_5	53.6 (11)[5]	5.2 (22)	90
SS	45 (7)	3.1 (23)	93
NO_2	0.04 (11)	0.43 (19)	91
NO_3	0.16 (10)	14.3 (23)	99
NH_3	49.1 (10)	13.6 (20)	72
TKN	76.3 (8)	16.9 (21)	78
TN	76.5 (8)	31.8 (21)	58
FC	3.4×10^5 (10)	2832 (22)	99 (2 logs)
TC	7.0×10^5 (5)	3590 (8)	99 (2 logs)

---

[1] Wastewater was from a sawmill and mill office building.

[2] Characteristics are from an intermittent recirculating sand filter (the 1st of 2 sand filters) operated from June 1979 to July 1980.

[3] BOD_5, SS and nitrogen expressed as mg/l; arithmetic mean.

[4] Fecal and total coliform expressed as org/100 ml; geometric mean.

[5] Number of samples.

TABLE 4-12. THE RELATIONSHIP BETWEEN INTERMITTENT RECIRCULATING SAND FILTER SEPTIC TANK EFFLUENT ABSORPTION BED MATTING AND FILTER TREATMENT (SYSTEM 9)[1]

PERIOD	BOD_5	SS	NO_2	NO_3	NH_3	TKN	TN	FC	TC
Before Clog[2] Mat Formation	6.6 (5)[3]	4.6 (5)	0.27 (3)	8.43 (4)	3.42 (1)	4.0 (1)	12.7 (4)	5,175 (5)	6,000 (3)
After Mat[4] Formation	3.6 (14)	2.9 (15)	0.36 (12)	18.0 (15)	12.1 (15)	14.3 (15)	32.8 (15)	1,716 (14)	2,432 (3)
Early Stages[5] of Bed Failure	5.3 (4)	3.0 (3)	0.52 (3)	6.1 (3)	21.6 (4)	27.3 (4)	33.9 (4)	4,989 (3)	---

[1] BOD_5, SS and nitrogen expressed as mg/l, arithmetic mean. Fecal and total coliform expressed as org/100 ml; geometric mean.

[2] The first 90 days of operation before a visible clog mat formed.

[3] Number of samples.

[4] 168 day period between the first visible signs of mat formation and filter bed failure.

[5] A 54 day period following the first indications of filter septic tank effluent injection bed failure.

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TABLE 4-13. INTERMITTENT RECIRCULATING SAND FILTER OPERATION AND MAINTENANCE NEEDS

FEATURE System	1 (TURNER)	2 (ROBERTS)	3 (McCLAFLIN)	4 (REBER)	5 (GROOMS)	6 (CHESTER)	7 (MATTESON)	8 (STEIDLEY)	9 (INT'L PAPER CO)
Weeds or Leaves on[1] Filter Surface	Yes (A)(W)(L)	Yes (W)(A)	Yes (W)	Yes (W)(L)	Yes (W)(L)	Yes (A)(W)(L)	Yes (W)	Yes (A)(W)(L)	No
Homeowner Weeded and Raked Filter Surface	No	Yes	Yes	Yes	No	No	No	No	---
Pump Shut Off By Homeowner to Control Weeds	No	Yes	Yes	No	No	Yes	No	No	---
Orifices Clogged[2] by Grit or Organic Matter	Yes (G)(OM)	Yes (G)	Yes (G)	No	No	Yes (G)	Yes (G)(OM)	Yes (G)(OM)	No
Homeowner Cleared Clogged Orifices	No	Yes	No	---	---	No	Yes	No	---
Overspray Beyond Filter Enclosure	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No
Filter Trenches Clogged by Biomat	Yes (11 mos.)	Yes (19 mos.)	Partial (2"; 29 mos.)	Yes (10 mos.)	No	Yes (27 mos.)	No	Yes (15 mos.)	Yes (8 mos.)
Effluent Ponded at Filter Surface	Yes	No	No	Yes	No	No	No	Yes	Yes
Sewage Odor Outside Filter	Yes	No	No	Yes	No	No	No	Yes	No
Pump Failure	No	Yes	Yes	No	No	No	No	No	No
Months Filter[3] Observed	14	20	29	11	9	33	14	21	14[4]
Times Observed	14	13	12	7	5	61	16	46	24

[1] (A) = algae; (W) = weeds; and (L) = leaf and needle fall.

[2] G = grit; and (OM) = earthworms and other forms of organic matter.

[3] Number of observations recorded for Systems 6-9 reflects those made by both Lane County Department of Environmental Mangement and DEQ staffs.

[4] Number of months observed reflects the length of time System 9 was observed before it was reconstructed.

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Due to its heavier hydraulic load, System 9 removed fecal indicators less efficiently (2 logs) than Systems 1-7 (4 logs). Bouma et al., (9) reported a similar decline in bacterial removal under conditions of quasi-saturated flow.

As was the case with residential sand filters, treatment provided by System 9 improved with the formation of a biomat and declined once effluent ponded in the bed to vent to the filter surface (Table 4-12).

FILTER OPERATION AND MAINTENANCE

Because of their exposure to the atmosphere, filter surfaces (Systems 1 to 8) were subjected to freezing, accumulation of leaves, needles, and other fallen debris, and weed growth (Table 4-13).

Systems 1 to 8 iced over during a period of cold (10-20 ° F) weather and freezing rain in late January 1980. Effluent applied at each recirculation cycle added to the filter ice mass. Ice accumulated at System 1 to the extent it dislodged fencing which surrounded the filter. When this occurred, sprayed effluent ran outside the filter.

Since recirculation tanks were placed immediately outside filters, no check valves were used along pressure distribution piping between recirculation pumps and filter spray heads. This permitted effluent remaining in pressure distribution piping to drain back to the recirculation tank at the end of each pump cycle and prevented spray head freezing.

Algae, grasses, and many other weeds grew abundantly on filter surfaces during spring, summer and early fall months. Leaf litter removal and weeding were required at least once each spring and fall. System users generally failed to provide this maintenance. Only three filter owners (37.5%) kept their filters routinely weeded and raked. And, as a weed control measure, three system owners turned their recirculation pumps off for extended periods during summer months.

When dense weeds were allowed to accumulate at System 1, a thin organic mat developed over the filter surface. The mat caused sprayed effluent to pond in a number of small local depressions. However, sands immediately below the filter surface remained unsaturated. Once the mat was punctured, ponded effluent quickly drained into filter sands.

Sprayhead orifices at 5 systems became clogged by grit, earthworms and other organic matter. Recirculation pumps at Systems 1, 6, 7 and 8 were placed directly on pump tank floors. Small pieces of concrete, sand, and other gritty debris were discharged with pumped effluent for several weeks following system startup. During that time, orifices frequently became clogged by these materials. Recirculation pumps in Systems 3, 4, and 5 were placed on 8 in. high concrete blocks. Orifices in those systems remained unclogged.

Earthworms occasionally clogged the sprayhead orifices of Systems 1, 7, and 8. It appeared worms had been pumped to sprayheads from recirculation tanks.

Although sprayheads were readily removable and accessible for cleaning, system users generally failed to perform this maintenance.

Overspray occurred at all filters open to the atmosphere except System 4 which was lined with corrugated plastic sheeting which prevented overspray from passing outside that filter. At each recirculation cycle, a small amount of sprayed effluent passed between board fencing which enclosed Systems 1, 2, 5, 6, 7, and 8. Overspray also passed beyond the concrete container wall of System 3. A fenced enclosure was never constructed around that filter.

Spray from shrub heads displaced a minor amount of sand in all systems. However, sand displacement did not appear to interfere with filter performance.

With continued use, filter septic tank effluent infiltration trenches in Systems 1, 2, 4, 6, 8 and 9 became completely clogged by a biomat. A mat also formed at the base and part way up the sidewall (2 in.) of System 3. However, complete matting did not occur at that system during the monitoring period. System 5 was replaced with an intermittent sand filter (Chapter 3) following 7 months use. The degree of filter trench matting was not determined during the time it was operated.

Trench matting was never apparent in System 7. Low hydraulic loading and wastewater with limited organic strength probably explain why clogging was never observed.

Prolonged application of septic tank effluent to filter absorption trenches caused a biomat to form at the trench gravel-sand interface within a few months (generally 60-120 days) of filter use.

Matting appeared at trench bottoms first. After absorption trench bottoms matted, infiltration decreased to the extent sidewall area was required to dispose of the hydraulic load. In time, effluent ponded in trenches. The depth of ponding corresponded to the height of the biomat at trench sidewalls. Matting eventually formed over the total trench infiltrative surface. When this occurred, the effluent infiltration rate was not sufficient to absorb all applied effluent so ponded effluent was forced to vent to the filter surface. Bouma et al., (9) and McGauhey and Winneberger (12) reported similar decreases in infiltration rates with biomat formation in field studies where absorption trenches were subjected to continued application of septic tank effluent.

Data (Table 4-14) suggested septic tank effluent quality had considerable impact on the rate of filter infiltration trench clogging. Systems 2 and 3 received approximately the same hydraulic load and used similar filter

TABLE 4-14. THE RELATIONSHIP BETWEEN BIOMAT FORMATION IN INTERMITTENT RECIRCULATING SAND FILTER SEPTIC TANK EFFLUENT ABSORPTION TRENCHES WITH HYDRAULIC LOADING, INFLUENT BOD_5 AND SUSPENDED SOLIDS AND FILTER SAND CHARACTERISTICS

FEATURE System	2 (Roberts)	3 (McClaflin)	4 (Reber)
Ave. Daily Flow (gpd)	174	161	176
STE - BOD_5	348 (7)[1]	125 (16)	378 (7)
STE - SS	171 (7)	92 (7)	276 (7)
Sand Effective Size (mm)	0.27	0.3	0.3
Sand - Uniformity Coefficient	2.0	3.2	1.5
% Co. & V. Co. Sand in Filter Media	52	56	28
% Gravel in Filter Media	14	16	2
Filter Absorption Trench Infiltrative Surface (ft^2)	64	96	128
No. Months Before Trenches Completely Clogged by Biomat	21	Partially Clogged (2 in.) after 29 mos.	11

[1] Number of samples.

sands, but received effluents that had significantly different BOD_5 and SS contents. * After 30 months use, a biomat covered 36 ft^2 of trench

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* See Chapter 15 for a discussion on the abnormally low waste strength received by System 5.

infiltrative surface in System 3. The mat caused 2 in. of effluent to pond in trenches. Following 21 months use, the entire filter trench infiltrative surface (64 ft^2) of System 2 became clogged by a biomat. Matting caused permanent ponding in trenches.

Although it was difficult to determine whether BOD_5 or SS affected the rate of clogging the most, data strongly suggests septic tank effluent waste strength had measurable impact on the rate of clog mat formation. Several other investigators feel the concentration of BOD_5 and SS impacts the rate of mat formation (13, 14, 15, 16, 17).

A comparison of effluent received by System 2 and and System 4 supported observations reported by Weibel et al., (15) and Laak (16) that the rate of clogging in infiltration trenches which received septic tank effluent was directly related to the concentrations of suspended solids in wastewater.

Although filter sands used in System 4 were finer than those used in System 2, the infiltrative surface of Filter 4's septic tank effluent infiltration trenches (128 ft^2) was two times greater than that of System 2 (64 ft^2) (Table 4-2). Both systems received similar hydraulic and BOD_5 loads, but System 4 received 61% (276 mg/l vs. 171 mg/l) more suspended solids than System 2 (Table 4-5). Trench infiltrative surfaces in System 4 became completely clogged by a biomat 10 months sooner than infiltrative surfaces in System 2.

Data indicated hydraulic loading affected the rate of filter infiltration trench clogging. Disposal trenches in System 1 received septic tank effluent at an average rate of 1.42 gal/ft^2/d (Table 4-3), 0.2 gal/ft^2/d greater than the clog equilibrium rate reported for medium sand by Bouma et al., (9, 18). In addition to septic tank effluent, trenches received an additional hydraulic load with each recirculation cycle. By the end of eleven months, trenches in System 1 had become completely clogged by a biomat.

System 9 was also influenced by a high hydraulic loading rate (4.4 gal/ft^2/d). Trenches clogged after the system had been in operation 8 months. The relatively low septic tank effluent waste strength received by System 9 (Table 4-11) probably caused the rate of biomat development to be slower than it would have been had the filter received residential septic tank effluent. Average BOD_5 and SS concentrations in residential septic tank effluents (Table 4-5) were approximately 4 times and 3 times higher, respectively, than those contained in effluent discharged to System 9.

The influence of groundwater infiltration on biomat formation was also apparent at System 8. Infiltrated groundwater accelerated the rate of mat formation in that system.

No data were available to determine the influence septic tank effluent waste strength and hydraulic loading had on the rate of crust formation at other filters.

One to 2 months after septic tank effluent infiltration trench biomatting forced wastewater to vent to the filter surface (Systems 1, 4, 8, and 9), a second biomat formed at the sand filter surface (Table 4-13). Matting caused a mixture of septic tank and filtered effluents to pond continuously above the filter. Sands beneath the mat remained moist, but unsaturated. When matting was disrupted by scraping the filter surface, ponded water quickly drained into sands. However, matting quickly reformed. When ponded water was allowed to stand over the surface of System 1 for 2 months, the biomat thickened to approximately 1/4 in.

Four to six weeks after filter surface matting appeared at Systems 1 and 8, ponded effluent accumulated to the point it spilled over filter containers.

A definite sewage odor accompanied surface matting and subsequent ponding (Systems 1, 4, and 8). Since System 9 was enclosed, odors were not apparent until one entered the structure housing that filter.

During summer months, mosquito larvae were observed in effluent ponded over System 8.

Pump failures occurred at Systems 2 and 3. The recirculation pump at System 2 burned out after 18 months operation. Failure was attributed to a wiring short. The recirculation pump at System 3 burned out twice.

The first failure occurred after 19 months operation. A second pump failure occurred following four months use. Both failures were attributed to motor burn out. System 3 was located in a rural area which may have been subjected to wide variations in power. This may have been responsible for pump motor burn out.

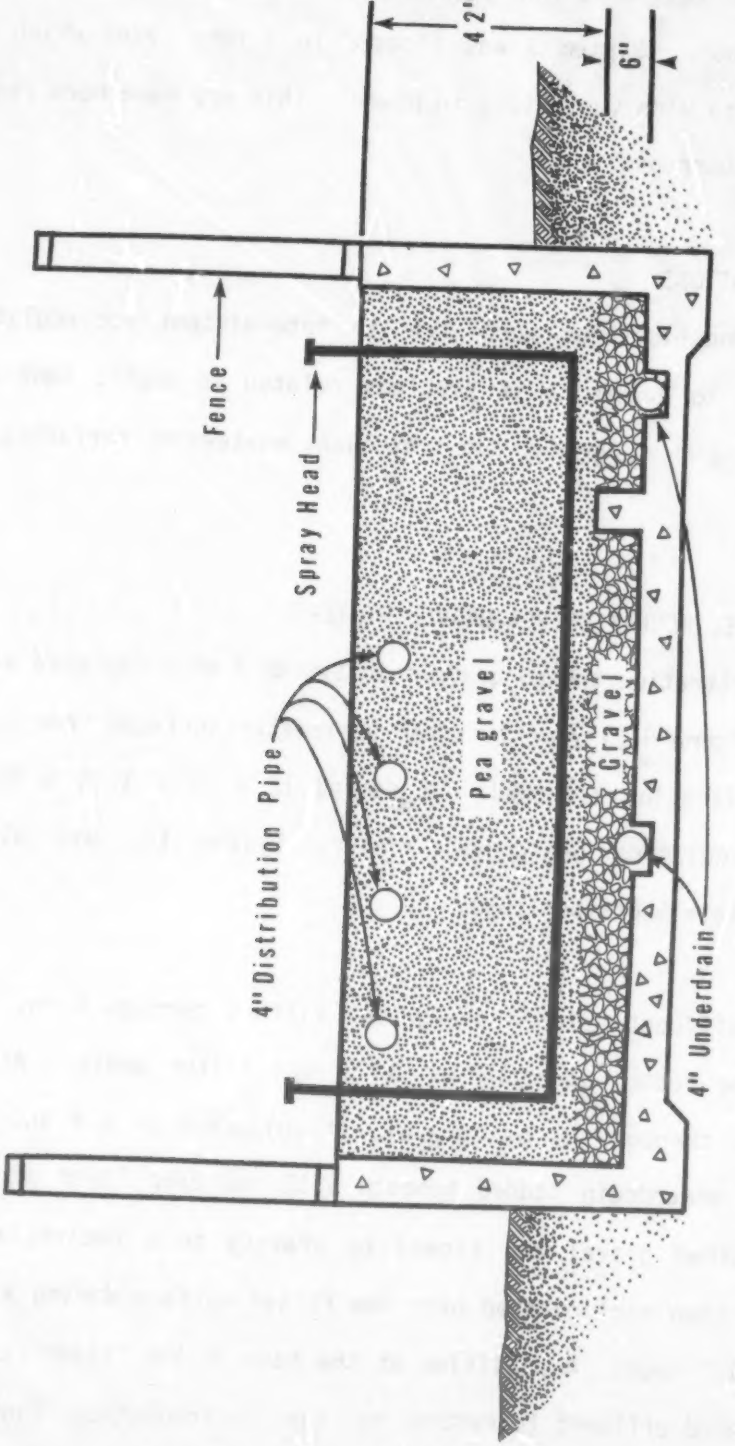
FILTER MODIFICATIONS

A number of modifications were made to intermittent recirculating sand filter systems to determine if problems related to septic tank effluent, infiltration trench clogging, and subsequent wastewater surfacing could be overcome.

INTERMITTENT RECIRCULATING PEA-GRAVEL FILTERS

Sands and infiltration trench gravels in System 4 were replaced with 3-6 mm pea-gravel (Figure 4-2) shortly after wastewater surfaced from septic tank effluent infiltration trenches. A second 12 x 12 x 3 ft 6 in. intermittent recirculating pea-gravel filter, System 10, was placed into operation in late September 1980.

Septic tank effluent entered pea-gravel filters through 4 in. perforated plastic piping bedded directly in pea-gravel filter media. After wastewater drained through the pea-gravel, it collected in a 4 in. perforated plastic pipe underdrain bedded beneath a 12 in. deep layer of 3/4 in. to 2-1/2 in. washed gravel and flowed by gravity to a recirculation tank. Effluent was then recirculated over the filter surface during a 1-5 minute period each 1/2 hour. A partition at the base of the filter caused 3/4 of the recirculated effluent to return to the recirculation tank. The



4'2"
6"
Fence
Spray Head
4" Distribution Pipe
Pea gravel
Gravel
4" Underdrain

FIGURE 4-2. INTERMITTENT RECIRCULATING PEA-GRAVEL FILTER

remainder of the effluent drained to subsurface disposal trenches.

A limited amount of data was collected to characterize pea-gravel filter effluent quality. Pea-gravel filters lowered BOD_5 and SS 95% (Table 4-15). These reductions were somewhat higher than decreases reported by University of Illinois researchers who studied recirculating pea-gravel filters (19).

Pea-gravel filtration reduced total nitrogen 52%. Ninety-seven percent of the nitrogen in pea-gravel filter effluent was oxidized compared to less than 1% in septic tank effluent. These results were similar to results obtained from recirculating sand filters and intermittent sand filters (Chapters 2 and 3) but indicated a much higher level of nitrification than Illinois recirculating pea-gravel filter studies (19). The higher dose volumes (150 gal/recirculation event vs. 15-25 gal/recirculation event) and lower dosing frequencies (5 times/d vs. 48 times/d) used in Illinois filter studies probably account for differences in effluent findings.

Data suggested septic tank effluent underwent a period of nitrification which was followed by a period of denitrification. Since no water ponded at the pea-gravel, underdrain-gravel interface, observations suggested the majority of the denitrification took place in moisture films coating gravels and at points of gravel contact.

Pea-gravel filters reduced fecal coliforms by 2 logs and total coliforms by 1 log. The rate of flow and number of passes through filter media determined bacterial removal (See Chapter 2).

So little data was collected, it was difficult to determine what caused the variations in effluent quality produced by Systems 4 and 10 (Table 4-16). Temperature and moisture conditions at the time filters were placed into operation may have affected their performance. System 4 was placed into use during warm, dry summer months while System 10 was placed into operation during cool, moist spring months.

TABLE 4-15. A COMPARISON BETWEEN SINGLE FAMILY RESIDENTIAL SEPTIC TANK AND INTERMITTENT RECIRCULATING PEA-GRAVEL FILTER EFFLUENTS[1]

EFFLUENT CHARACTERISTIC	SEPTIC TANK EFFLUENT	INTERMITTENT RECIRCULATING PEA-GRAVEL FILTER EFFLUENT	% CHANGE
BOD_5	326 (7)[2]	18 (7)	95
SS	185 (6)	8.6 (5)	95
NO_2	0.02 (6)	0.57 (6)	96
NO_3	0.19 (7)	28.5 (6)	99
NH_3	46.4 (7)	0.9 (6)	98
TKN	64.8 (6)	2.0 (5)	97
TN	65.0 (6)	31.3 (6)	52
FC	3.56×10^5 (5)	6.9×10^3 (5)	98 (2 logs)
TC	6.5×10^5 (5)	1.5×10^4 (5)	98 (1 log)

---

[1] BOD_5, SS and nitrogen expressed as mg/l; arithmetic mean. Fecal and total coliform expressed as org/100 ml; geometric mean (average of 2 systems, Table 2-16).

[2] Number of samples.

TABLE 4-16. A COMPARISON BETWEEN 2 SINGLE FAMILY RESIDENTIAL SEPTIC TANK AND INTERMITTENT RECIRCULATING PEA-GRAVEL FILTER EFFLUENTS[1]

		SEPTIC TANK EFFLUENT CHARACTERISTICS									PEA GRAVEL FILTER EFFLUENT CHARACTERISTICS								
SYSTEM	AVE[2] FLOW (gpd)	BOD_5	SS	NO_2	NO_3	NH_3	TKN	TN	FC	TC	BOD_5	SS	NO_2	NO_3	NH_3	TKN	TN	FC	TC
4 (Reber)	182	329 (4)[3]	175 (4)	0.02 (4)	0.15 (4)	56.7 (4)	73.6 (4)	73.8 (4)	5.4×10^5 (3)	2.1×10^5 (3)	2 (4)	2 (4)	0.1 (4)	37.6 (4)	0.37 (4)	1.1 (4)	38.7 (4)	748 (3)	1,482 (3)
10 (Anderson)	---	322 (3)	203 (2)	0.02 (3)	0.24 (3)	32.6 (3)	47.2 (2)	47.5 (2)	8.1×10^4 (2)	1.3×10^6 (2)	39.33 (3)	35 (1)	0.52 (2)	10.24 (2)	1.58 (2)	5.4 (2)	16.2 (2)	16,193 (2)	36,332 (2)
Weighted Arithmetic Average	182 (1)	326 (7)	185 (6)	0.02 (6)	0.19 (7)	46.4 (7)	64.8 (6)	65.0 (6)	3.56×10^5 (5)	6.5×10^5 (5)	18 (7)	8.6 (5)	0.57 (6)	28.5 (6)	0.9 (6)	2.0 (5)	31.3 (6)	6.9×10^3 (5)	1.5×10^4 (5)

---

[1] BOD_5, SS, and nitrogen expressed as mg/l; arithmetic mean. Fecal and total coliform expressed as org/100 ml; geometric mean.

[2] No flow was recorded for System 10.

[3] Number of samples.

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System 4 was located in an area where the mean annual temperature was 53.7 °F and annual precipitation ranged from 32-35 in. System 10 was located in an area where the mean temperature averaged 51.3 °F and annual precipitation was around 50 in. (20).

Data (not shown) also suggested the quality of effluent from System 10 improved with time, indicating mean values reported for that filter may not be representative of that system's eventual treatment capability.

Pea-gravel filters required periodic weeding and spray head cleaning. With each recirculation event, a small amount of sprayed effluent passed through cracks between wooden fencing at System 10. During cool moist months, a slight odor was also apparent in the immediate vicinity of that filter. The inner plastic sheet lining System 4 prevented overspray from escaping from that system. No sewage odor was detectable at System 4.

Due to the coarse nature of their filter media, pea-gravel filters appeared to be considerably less susceptible to filter biomat clogging and freezing than intermittent recirculating sand filters. Pea-gravel filters showed no indication of media clogging during the period they were monitored.

After 16 months operation a thin gray film of what appeared to be organic matter coated pea-gravel media at System 10. A similar film was not apparent at System 4 following 9 months use.

ALTERNATE RESTING AND DOSING OF FILTER EFFLUENT ABSORPTION TRENCHES

Manually operated dosing valves (3 in. diameter recreational vehicle waste dump valves) were installed at Systems 6 and 8 to determine if resting of biomat clogged septic tank effluent infiltration trenches would restore them to their original permeability (18). After 27 months operation, the 2 original septic tank effluent infiltration trenches in System 6 became completely clogged by a biomat. At that time, a third, deeper (24 in. deep with an 18 in. layer of crushed rock) wider (30 in.) effluent infiltration trench was installed 8 in. inside existing trenches. Dump valves were placed ahead of trenches and all flow was directed into the new trench. After 30 days resting, the majority of the biomat which bordered the 2 original trenches had dissipated. After 60 days resting, matting had almost completely disappeared (13). These results are similar to findings reported by University of Wisconsin researchers (21) and Wiegand (22) in his field studies of alternating systems in West Virginia.

Similar resting of a septic tank effluent infiltration trench in System 8 failed to appreciably increase that trench's infiltration rate. When flow to one of System 8's 2 trenches was blocked off, the hydraulic load to the trench left in service was sufficient to cause effluent to surface. This resulted in the formation of a second biomat and subsequent ponding over the filter. These conditions caused sands adjacent to the rested trench to remain anaerobic which substantially interfered with the rate of biomat decomposition.

INTERMITTENT RECIRCULATING GRAVEL-SAND FILTER

Following 11 months operation, System 9 was redesigned to process a hydraulic load of 5.9 gal/ft^2/d. Sands and gravels from the original filter were replaced with a central 450 ft^2 cell of coarse media (effective size 3.2 mm; uniformity coefficient 1.68) and 2-113 ft^2 polishing cells (Figure 4-3). One polishing cell contained the same sized media as the central cell. The other contained medium sand (effective size 0.35 mm; uniformity coefficient 3.18).

Septic tank effluent injection cycles and recirculation events were doubled to offset the filter's smaller surface area. Septic tank effluent was pumped to the large central cell 96 times per day. Filtered effluent was recirculated over the entire filter surface at intervals between septic tank effluent injection events. Septic tank effluent injection events and recirculation events were controlled by separate 30-minute time clock controls.

A small amount of data was gathered from the intermittent recirculating gravel-sand filter to characterize septic tank, coarse media and sand polishing media effluents. Preliminary information indicated the filter provided a high degree of treatment (Table 4-17). Filtration through the gravel cell lowered BOD_5 93%, SS 91%, and fecal indicators 2 logs.

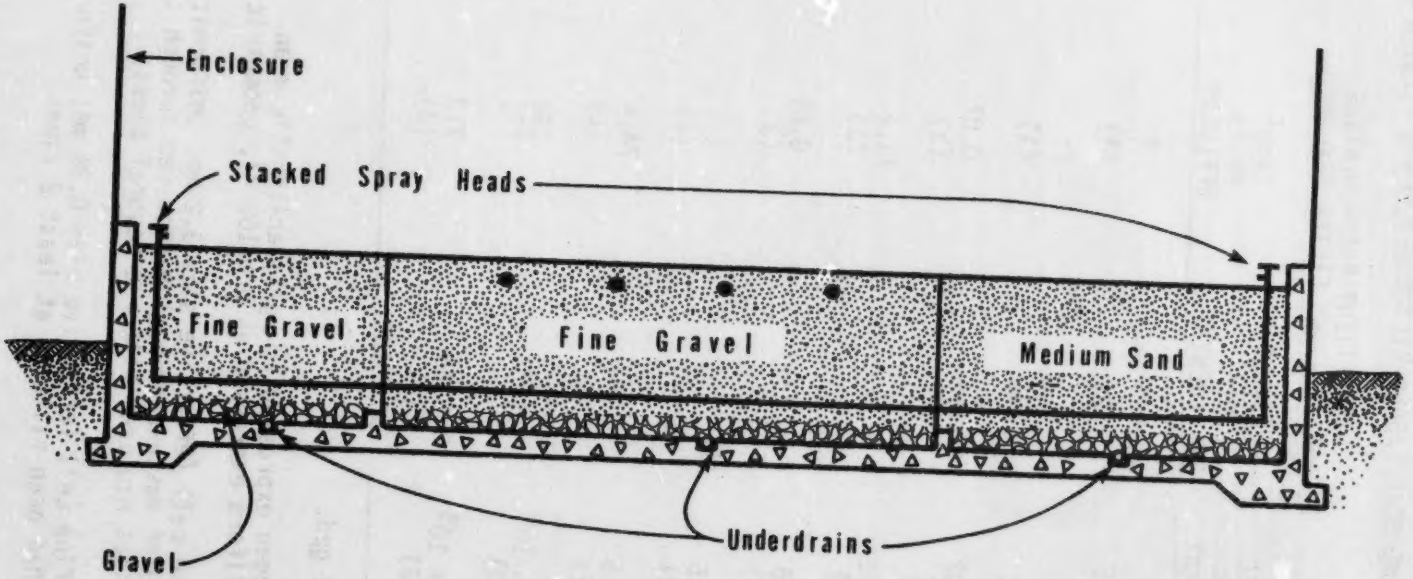
Enclosure
Stacked Spray Heads
Fine Gravel
Fine Gravel
Medium Sand
Gravel
Underdrains

FIGURE 4-3. INDUSTRIAL INTERMITTENT RECIRCULATING GRAVEL-SAND FILTER

TABLE 4-17. A COMPARISON BETWEEN INDUSTRIAL SEPTIC TANK AND INTERMITTENT RECIRCULATING GRAVEL/SAND FILTER EFFLUENTS (SYSTEM 9)[1,2]

EFFLUENT CHARACTERISTIC	SEPTIC TANK EFFLUENT	INTERMITTENT RECIRCULATING GRAVEL/SAND FILTER EFFLUENT		% CHANGE
		GRAVEL[3] MEDIA EFFLUENT	SAND[4] MEDIA EFFLUENT	
BOD_5	69 (3)[5]	4.5 (2)	3 (3)	96
SS	77 (2)	7.0 (1)	11 (1)	86
NO_2	0.02 (3)	---	0.07 (3)	71
NO_3	0.08 (2)	---	73.2 (3)	99
NH_3	60.8 (3)	---	0.85 (3)	99
TKN	112.5 (2)	---	1.1 (1)	99
TN	112.6 (2)	---	74.4 (1)	34
FC	1.58×10^5 (2)	4336 (2)	169 (3)	99 (3 logs)
TC	3.46×10^5 (2)	9165 (2)	713 (3)	99 (3 logs)

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[1] Flow averaged 5,000 gpd.

[2] BOD_5, SS, and nitrogen expressed as mg/l; arithmetic mean. Fecal and total coliform expressed as org/100 ml; geometric mean.

[3] Effluent from coarse cell (effective size 3.2 mm; uniformity coefficient 1.68) was a mixture of wastewater that had passed through the filter one time and effluent that had been filtered several times.

[4] Effluent from the fine cell (effective size 0.36 mm; uniformity coefficient 3.18) had been filtered at least 2 times.

[5] Number of data points.

Recirculation through System 9's polishing cell reduced BOD_5 96% and SS 86%. Suspended solids levels were probably lower in coarse cell effluent than they were in medium sand polishing cell effluent because clay and silt sized particles washed from treatment sand added to solids values. Total nitrogen in polishing cell effluent was reduced 34%. Ninety nine percent of the nitrogen in sand filter effluent was in the nitrate form compared to less than 1% in septic tank effluent.

Recirculation through polishing cell sands decreased total and fecal coliform organisms by 3 logs. It appears the pores between polishing sands were small enough to decrease the rate of flow sufficiently to allow good bacterial removal to occur.

The intermittent recirculating gravel-sand filter was observed on June 3, 1981 and March 4, 1982 to determine its operating condition and maintenance needs (3). Filter sands and sprinkler heads were not clogged. No odors were detected within the filter enclosure or within the media just below the septic tank effluent injection bed. A thin, gray, "tacky" film coated the treatment media at the interface between the pressure injection bed and the coarse filter media. However, no biological growth appeared to clog interstitial areas between media. One of the septic tank effluent pressure distribution laterals was cleaned out June 3, 1981 to determine if foreign matter was present. The lateral contained 2 cigarette filters and considerable hair. As a result, a protective plastic screen was installed around the dosing pump to prevent neutral buoyancy articles from entering the effluent distribution system (3).

DISPOSAL FIELD PERFORMANCE

All intermittent recirculating sand filters discharged effluent to 2 ft deep, 2 ft wide soil absorption trenches which contained 4 in. diameter perforated plastic distribution piping bedded in a 12 in. layer of washed gravel.

Disposal trench systems behind Systems 1, 4, 5, 6, 7, and 8 were placed in soils limited by shallowness to fragipans, claypans and saprolite. These soils had seasonal groundwater tables during wet fall, winter and spring months. Disposal trenches at Systems 2 and 3 were located where clayey subsoils were shallow to weathered basalt. The disposal field behind System 9 was installed in deep, well drained silty clay loam soils.

Trench water levels were observed at Systems 1, 2, 3, 4, and 9 (Table 4-18). In spite of the fact Systems 1 to 4 were located in soils limited by shallowness to subsoil pans, saprolite and/or seasonal groundwater, disposal fields at those locations operated satisfactorily.

During wet winter months, infiltrated ground and surface waters accumulated in the lower 4 to 6 in. of Systems 1 and 4. Water levels corresponded to the depths trenches penetrated into slowly permeable fragipan (System 1) and claypan (System 2) materials. Water levels receded during dry summer months. At that time, the total wastewater load to each system was absorbed by its first disposal trench (Data not shown).

Disposal trenches at System 5 were installed in heavy silty clay loam soils

17 to 24 in. to clayey subsoils. Trenches were excavated following a period of heavy rainfall. During construction, soils bordering trench bottoms and sidewalls were smeared and compacted. When disposal lines were backfilled 4 to 8 in. of topsoil was scraped off the soil absorption field. As a result, as little as 4 in. unsettled backfill covered disposal trench aggregate in several locations. The combination of smeared, compacted soils and trench shallowness caused infiltrated ground and surface water to seep continuously from trenches throughout the winter and spring of 1980. Since soil damage was too extensive to permit trenches to be reestablished in the initial disposal field area, System 5 was replaced by an intermittent sand filter at a location where well drained soils were shallow to basalt saprolite (Chapter 3).

Trench water levels were not observed at Systems 6 and 7. Both filter systems were constructed to replace failing (surfacing) disposal fields. System 6 drained to 2-75 ft long disposal trenches and System 7 discharged to 100 linear ft of disposal trench. During the period filters were monitored, no surfacing was evident in the vicinity of either system's soil absorption trenches.

System 8 was also installed to replace a failing disposal field. Hydraulic overloading caused a mixture of partially treated septic tank effluent and infiltrated groundwater to surface from disposal trenches during wet months. Disposal trenches were installed 4-6 in. into a dense claypan.

System 9 data (Table 4-18) dramatically demonstrated the impact sand filter

TABLE 4-18. A DESCRIPTION OF SITE CONDITIONS, SOIL ABSORPTION TRENCHES, AND TRENCH PERFORMANCE AT 5 INTERMITTENT RECIRCULATING SAND FILTER SYSTEM LOCATIONS [1,2]

	SYSTEM				
FEATURE DESCRIBED	1 (TURNER)	2 (ROBERTS)	3 (McCLAFLIN)	4 (REBER)	9 (INT. PAPER CORP.)
Soil Absorption System Site Limitation	seasonal groundwater; mottling at 18 in.; dense fragipan at 18 in.	20-31 in. to clayey subsoil suspected to be restrictive; no mottling evident	slowly permeable gravelly clay at 20 in.	seasonal groundwater mottling at 18-20 in.; dense claypan 20-35 in.	none[3]
Soil Texture at Absorption Trench Sidewall	silt loam	20-31 in. clay loam over clay	20 in. cobbly, silty clay loam over gravelly clay	20-35 in. silty clay loam over a dense clay pan	13 in. silt loam over 26 in. silty clay loam over silty clay
Slope (%)	10	7-9	25	5	5
Average Drainfield Loading Rate (gpd)	278	174	161	196	3000
Trench Type, Length,[1] and Sidewall Absorption Area (ft^2)	4-serial trenches 500 lin. ft. (1000)	6-serial trenches 375 lin. ft. (750)	5-serial trenches 500 lin. ft (1000)	7-serial trenches 455 lin. ft. (910)	8-serial trenches 480 lin. ft. (960)
Average Daily Trench Sidewall Loading Rate (g/ft^2/d)	4.45	too rapid to determine	19.3	2.25	20.68
Average Percent System[2] Sidewall Used for Absorbing Effluent	6.25	too rapid to determine	1.66	9.52	14.58
Trench Installation Date	November 1978	November 1979	October 1979	June 1979	June 1979
Observation Period	Jan. 1979-Mar. 1980	Nov. 1979-May 1981	Jan. 1979-April 1980	Nov. 1979-Mar. 1981	July 1979-April 1980
Number of Observations	15	13	10	10	24

[1] Average trench depth was 24 in.: trenches contained 12 in. washed gravel and were gravity fed through 4 in. diameter perforated plastic distribution piping.

[2] Average percent sidewall used for absorbing sand filtered effluent was determined during dryer summer months at Systems 1 and 4 since trench sidewalls were often totally or partially inundated by groundwater during high precipitation months (November-April). Percent sidewall absorbing effluent was determined during high precipitation months at Filter Systems 2 and 3.

[3] System was installed as a repair since insufficient area was available for the installation of a conventional septic tank-soil absorption system.

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treatment had on the rate effluent was accepted by soil absorption trenches. The first 4-1/2 months System 9 was in operation, all treated effluent was absorbed by 60 linear ft of disposal trench. After that, in response to periods of heavy precipitation, effluent occasionally drained from the first drop box to a second 60 ft long disposal trench. An average of 25 gal/ft^2/d sand filtered effluent was absorbed by the first disposal trench during warm, dry months. Effluent was absorbed by trenches at a rate in excess of 12.5 gal/ft^2/d during wet months (November through March when precipitation averaged 5.36, 6.25, 6.65, 4.5, and 4.3 in. per month respectively) (20, 23).

During the period System 9 was being reconstructed, septic tank effluent was routed to a drop box at the entry to the system's fifth disposal trench. By the time filter reconstruction was completed (two months later), septic tank effluent had ponded in three serial trenches and part of a fourth trench (trenches 5, 6, 7, and 8). This was greater than 400 ft^2 of trench sidewall. Very little (1.84 in.) rainfall fell during the interval the filter was being reconstructed (23).

When the intermittent recirculating gravel-sand filter was placed into operation, effluent was redirected to the first drop box. Thirteen months after the system was placed on line all filtered effluent was being absorbed by the first disposal trench (3).

The treatment of septic tank effluent by intermittent recirculating sand filtration stops or substantially reduces the rate of soil biomat formation. Although investigators disagree on which factor plays the most active role in biomat development, sand filtration markedly decreases BOD_5, SS, and fecal bacterial organisms, the agents researchers feel are primarily responsible for soil clogging (13, 14, 15, 16, 24, 25).

Soil absorption trenches following Systems 1, 6, and 9 were unearthed after systems had operated 14, 31, and 8 months respectively, to determine if biological matting had developed at trench gravel-soil interfaces. Observations were made during the wettest time of the year when conditions favoring mat development were the most intensive. No indication of organic slimes or biomat development was evident at any trench interface. Trench gravels were unstained. Water in trenches was clear and odorless.

A pale, gray filamentous biological growth of what appeared to be slime bacteria of the Sphaerotilus-Leptotrix group was observed on the inlet and walls of the drop box leading to System 9's first disposal trench. No organic sediments were found at the bottom of the box.

When BOD_5, SS, and fecal organisms were reduced by intermittent recirculating sand filtration, soil absorption trench effluent acceptance rates remained high. Table 4-19 compares the mean rates filtered effluent was accepted by disposal trenches located in silt loam, silty clay loam, and clay loam soils with septic tank loading rates recommended by Bouma (26) and Machmeier (27) for deeper, better drained soils of the same texture. * Disposal trench examinations suggest filtered effluent was absorbed at high rates because biomats were absent.

TABLE 4-19. A COMPARISON BETWEEN INTERMITTENT RECIRCULATING SAND FILTER SOIL ABSORPTION TRENCH EFFLUENT ACCEPTANCE RATES AND SEPTIC TANK EFFLUENT LOADING RATES RECOMMENDED BY BOUMA AND MACHMEIER IN SIMILAR SOILS

SYSTEM	SOIL TEXTURE	FILTERED[1] EFFLUENT ACCEPTANCE RATE (gal/d/ft^2)	RECOMMENDED SEPTIC TANK[2] EFFLUENT LOADING RATE (gal/d/ft^2)	
			BOUMA	MACHMEIER
1 (Turner)	silt loam	4.45	0.72	0.50
2 (Roberts)	clay loam over clay	Too rapid to determine	0.24	0.45
3 (McClaflin)	Cobbly silty clay loam over gravelly clay	19.3	0.72	0.50
4 (Reber)	silty clay loam over claypan	9.52	0.72	0.50
9 (Int. Paper Co.)	silt loam over silty clay loam	20.68	0.72	0.50

[1] Based on sidewall area.

[2] Based on bottom area.

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* Exception: Disposal trenches following Filter 9 were placed in deep well-drained soils.

CONCLUSIONS

The surface of intermittent recirculating sand filters was subject to freezing, accumulation of vegetative debris and growth of weeds. Spray heads were subject to clogging by grit, earthworms and organic debris. Two pump failures occurred because of faulty wiring. Overspray occurred at all filters except System 4 which had the fencing lined with plastic to prevent overspray.

BOD_5, SS, and total nitrogen were reduced 98%, 98%, and 39% respectively. Denitrification probably occurred in anaerobic moisture films in sand grains and at points of sand grain contact and in the zone of near saturation just above the sand-gravel interface. Total and fecal coliform densities were reduced 4 logs.

A biomat eventually clogged septic tank effluent infiltration trenches in all but 2 sand filters. This resulted in ponding of effluent in infiltration trenches and on the sand filter surfaces. As a result, BOD_5 and SS increased sharply. Less than 2% of the nitrogen in filter effluent was nitrified and fecal coliform densities increased 3 logs. Failure was attributed mainly to hydraulic overloading.

Intermittent recirculating pea gravel sand filters reduced BOD_5 and SS 95% and total nitrogen 52%. Fecal coliform and total coliform densities were reduced by 2 logs and 1 log respectively.

Biological clogging and freezing were not a problem because of the coarse nature of the media.

Intermittent recirculating gravel-sand filtration reduced BOD_5, SS, and total nitrogen 96%, 86%, and 34% respectively. Total and fecal coliform densities were reduced 3 logs. No biological clogging has occurred to date.

No biomat or odor occurred in disposal trenches following intermittent recirculating sand filters. Observation of disposal trenches suggested that sand filtration of septic tank effluent increased disposal trench acceptance rates.

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CHAPTER 5

EFFECT OF TILE DRAINAGE ON DISPOSAL OF SEPTIC TANK EFFLUENT IN WET SOILS

The Willamette Valley in Western Oregon contains about 1,500,000 acres of soils with seasonally high water tables (1). These soils are not well suited for treatment and disposal of septic tank effluent due to anaerobic conditions which may occur in saturated disposal trenches. Accumulation of organic material and other products of anaerobic decomposition reduces the absorptive capacity of the soil system. In addition, saturated soils on level sites may not accept the additional hydraulic load from a disposal field. This combination of factors frequently results in effluent coming to ground surface.

Approximately 25% of the seasonally wet soils in the Willamette Valley are moderately well to somewhat poorly drained (1). Typically, these soils are medium to moderately fine textured, porous, and have moderate to moderately slow permeability. As a result, they are readily drained if outlets occur.

About 400,000 acres of these seasonally wet soils were drained between 1937 and 1964 (2) to increase agricultural production. Subsequently, many of these agricultural soils were developed for residential uses. The chief concern has been for the quality of drainage water discharged to outlets from tile lines that are in close proximity to disposal trenches.

Reneau (3) observed that migration of organisms from disposal trenches to an artificial drainage system did occur. He concluded that it was difficult to assess the adequacy of an artificial drainage system with respect to penetration of biological contaminants. Other researchers (4,5) described the potential for survival and movement of fecal organisms from septic tank effluent through a shallow, artificially saturated groundwater system. They suggested giving more attention to the public health implications of sewage movement through soil profiles.

Current health codes (6,7) assume that horizontal separation distances between disposal trenches and tile drainage lines as well as vertical separation distances between disposal trench bottoms and the highest level attained by groundwater are adequate. However, there is little data to indicate how much movement of fecal organisms occurs from subsurface disposal fields into groundwater and ultimately into tile drainage systems.

This study was conducted to determine if tile lines placed 4 and 6 ft deep with 10 and 20 ft horizontal separations, respectively, around disposal fields were adequate to effectively lower water tables and provide aerobic soil treatment of septic tank effluent.

MATERIALS AND METHODS

Special subsurface sewage disposal permits were issued by the Oregon Department of Environmental Quality to individuals who had been denied standard permits due to seasonally wet soil conditions. Oregon subsurface rules require a minimum depth to temporary (seasonal) groundwater of 24 in. from ground surface. Sites were initially evaluated by Department soil scientists to insure acceptable soil characteristics and adequate site relief to allow drainage system outlets.

SITE DESCRIPTIONS

The experimental area was located primarily on soils formed in old alluvial terraces of the Willamette Valley identified as the Senecal geomorphic surface (8). Soils specifically studied belong to the Woodburn and Aloha series.

The Woodburn series (Aquultic Argixeroll) consists of deep, moderately well drained soils formed in silty alluvium of mixed material or lacustrine silts. The Aloha series (Aquic Xerochept) consists of deep, somewhat poorly drained soils formed in old alluvium or lacustrine silts. Depth to groundwater varied from 9 to 36 in. Slope on all sites was 0-3%. Mean annual precipitation in the Willamette Valley is 40-50 in.; mean annual air temperature is 52 to 54° F.

SYSTEM DESIGN

Basic components of the systems studied were conventional disposal fields consisting of 2 ft deep trenches on 10 ft centers. Disposal fields were surrounded by 4 in. diameter perimeter drains installed 4 and 6 ft deep with a gradient of 0.3 ft/100 ft (Figure 5-1). Perimeter drains 4 ft deep were setback 10 ft from disposal trenches and perimeter drains 6 ft deep were setback 20 ft from disposal trenches. The downgradient junction of the perimeter drain was tied in to a 30 in. diameter silt trap

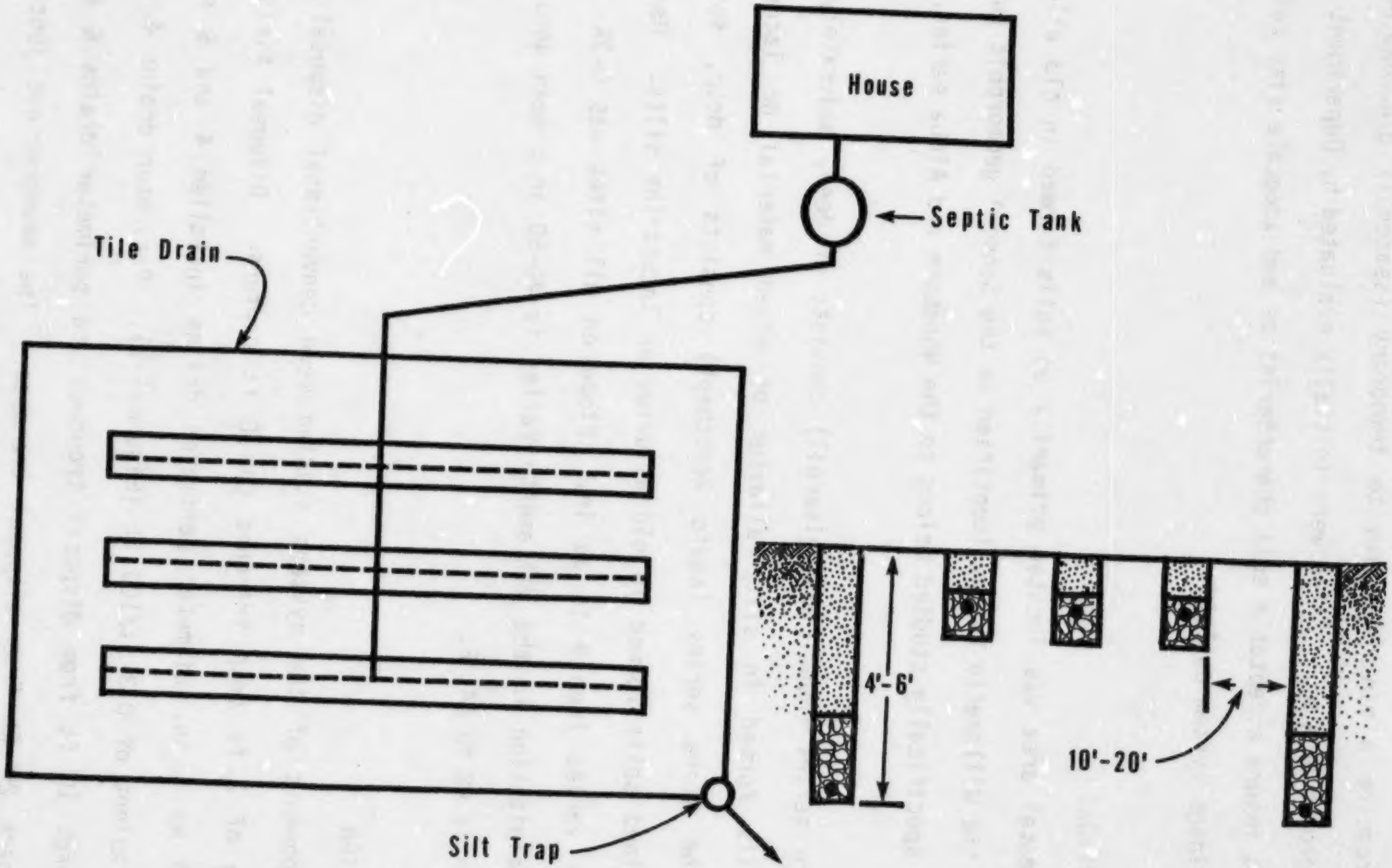
House
Septic Tank
Tile Drain
Silt Trap
4'-6'
10'-20'

FIGURE 5-1. TILE DEWATERING SYSTEM PLAN AND DETAIL OF PERIMETER DRAIN AND DISPOSAL FIELD

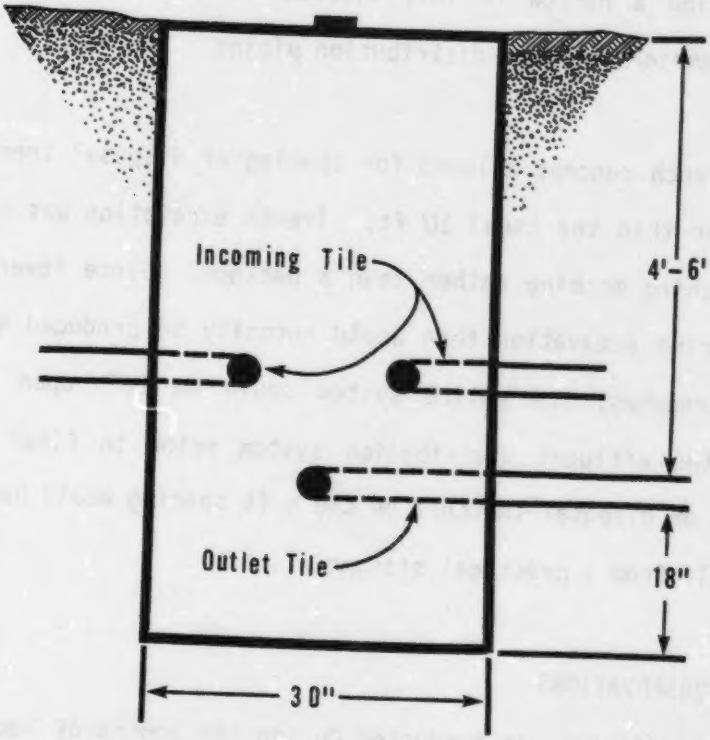
Incoming Tile
4'–6'
Outlet Tile
18"
30"

FIGURE 5-2. DETAIL OF SILT TRAP AND MONITORING PORTS

(Figure 5-2). The primary function of the silt trap was to provide monitoring points to sample drainage water.

As a further test of this approach, 3 systems with shallow (36 in. deep) perimeter drains were permitted and installed. To facilitate groundwater drawdown, field tile were spaced only 30 ft apart. This was accomplished by incorporating a narrow (6 in.) disposal trench into the design along with small diameter pressure distribution piping.

The narrow trench concept allowed for spacing of disposal trenches on 5 ft centers rather than the usual 10 ft. Trench excavation was simplified by using a trenching machine rather than a backhoe. Since fewer spoils were generated during excavation than would normally be produced with standard 2 ft wide trenches, the entire system could be left open for pressure testing of the effluent distribution system prior to final backfilling. Construction of disposal trenches on the 5 ft spacing would have otherwise been difficult from a practical standpoint.

WATER TABLE OBSERVATIONS

Groundwater monitoring was conducted during the months of December through March of 1979-80 and 1980-81. Water levels were measured inside the perimeter drain and at points outside of the perimeter drain beyond the drawdown influence of the drain tile. Water levels were observed in 4 in. diameter, PVC lined monitoring wells. Monitoring well dependability was periodically confirmed with observations in fresh auger bores.

DRAINAGE WATER QUALITY PARAMETERS

Two water quality samples were collected from monitoring points in the silt trap, one upgradient and one downgradient (Figure 5-2). Samples were taken on the same days water table observations were recorded.

Water quality parameters monitored were NO_3, total coliform bacteria and fecal coliform bacteria. Nitrate was determined colorimetrically by a cadmium reduction method (9). Bacterial analyses for total and fecal coliform were conducted using a membrane filter technique (10). Total fecal coliform densities were reported as log normalized means. Each observation reflected the assumption that flows from inlets into the silt trap were near equal in volume. Results for each analysis were therefore combined for each observation by averaging of the 2 numbers.

RESULTS AND DISCUSSION

WATER TABLE DRAWDOWN

Field tile perimeter drains in the disposal field area were effective in producing groundwater drawdown (Table 5-1). Results were similar to those obtained in adjacent agricultural lands where tile drains were designed and installed on a maximum spacing of 70 ft according to SCS (11) recommendations for effective drainage of these soils. Groundwater drawdown was greater where a 6 ft tile depth was used. The relatively small drawdown observed at System 4 was attributed to the influences of old field tile in an adjacent field which maintained groundwater levels below 36 in. outside the perimeter drain and disposal field. Soil mottling at this site indicated that groundwater normally occurred above 24 in.

Perimeter drains were installed with a minimum depth of 4 ft around Systems 6 through 9 with a 10 ft separation distance between tile lines and disposal trenches. Variations in relief resulted in portions of the perimeter drain being deeper than the 4 ft minimum. Consequently, ground water levels observed for Systems 7 and 9 were deeper than 4 ft. Groundwater drawdown for System 7 was comparable to other systems even though no gravel envelope was installed in the perimeter drain. Ground water levels in the disposal field area of System 6 were high relative to the other systems. The 33 in. mean value however is still well below the 24 in. minimum depth required under state rules (6).

TABLE 5-1. EFFECT OF TILE DRAINAGE ON GROUNDWATER LEVEL(1)

SYSTEM (Soil Texture)	Groundwater Depth Inside (in.)	Groundwater Depth Outside (in.)	Draw Down
Min. tile depth 6 ft			
1. silty clay loam	51	9	42
2. silty clay loam	57	11	46
3. silt loam	59	14	45
4. silt loam(2)	60	36	24
5. silt loam	53	16	37
Min. tile depth 4 ft			
6. silt loam	33	11	22
7. silty clay loam (3)	53	24	29
8. clay loam (2)	flooded......		
9. loam	56	13	43

(1) Observations taken December through March, 1980-81.
(2) Old field tile influence.
(3) No gravel envelope.

System 8 was flooded by an old field tile which was intersected during construction of the perimeter drain. The old line was excavated 20 ft upslope from the point of intersection and backfilled. The first heavy rains of the season caused water to surface from the line and run across the disposal field nearly continuously. Groundwater levels were not recorded in this system, but water quality samples were collected from monitoring points in the silt trap to indicate performance under saturated soil conditions.

Data for the performance of shallow (36 in. deep) perimeter drain systems was unavailable at the time of this report. One system was influenced so dramatically by older drainage tile in an adjacent field that no groundwater was ever observed in the perimeter drain area. Performance monitoring was, therefore, impossible.

Two additional shallow perimeter drains with narrow disposal trenches were installed but were not completed until after the monitoring season had ended. Groundwater drawdown observations for one of these systems indicated that the perimeter drain was effective in lowering water levels in the disposal field area (data not shown). Further monitoring of these systems would be very useful in determining potential as a cost-effective alternative on poorly drained sites with shallow effective soil depth and/or limited area.

DRAINAGE WATER QUALITY

Nitrate levels in monitored perimeter drain discharges were below the

USPHS minimum drinking water standard of 10 mg/1. The disposal field for System 7 did not receive septic tank effluent during the monitoring period (Table 5-2). However, the system was monitored for groundwater drawdown and drainage water was sampled for background. This system produced the highest mean nitrate levels (Table 5-2) and suggested that the other systems were not above background for this parameter. System 7 is located in a rural agricultural area and these nitrate levels were attributed to fertilizer practices.

TABLE 5-2. EFFECT OF DISPOSAL TRENCHES ON TILE DRAINAGE WATER

System	NO_3-N mg/1(1)	Total Coliform	Fecal Coliform	Observations(5)
		- - - - - # org/100 ml(2)	- - - - -	
		min. tile depth 6 ft, setback 20 ft		
1.	3.7	446	56	8
2.	0.6	1138	83	5
3.	2.3(3)	100	10	3
4.	3.1	2843	60	4
5.	4.1	3180	934	8
		min. tile depth 4 ft, setback 10 ft		
6.	1.0	3717	74	8
7.	5.0	643	18	8
8.	4.7(4)	67892	4130	3
9.	0.9	93	6	3

(1) Arithmetic mean.
(2) Geometric mean.
(3) Septic system unused.
(4) Drainfield flooded.
(5) Average value for samples from each of two inlets on given date.

Total and fecal coliform levels showed wider variation during the monitoring period. Fecal coliform levels were largely within the 200 org/100 ml minimum required under Water Quality standards (12). Systems 5 and 8, however, showed relatively high mean values for these parameters.

System 8, as noted earlier in this discussion, was flooded during the monitoring season. Conditions optimal for rapid saturated flow into the perimeter drain were present because the disposal field was saturated. Rahe et al., (4) showed that rapid translocation of organisms occurred under saturated flow on hillside landscape positions. Although System 8 was nearly level, a hydraulic gradient was produced by drawdown to the perimeter drain. This combination of factors presents an example of system performance under conditions of saturated flow. Performance of System 8 was not satisfactory. The existing field tile will either be diverted around the disposal field or be tied into the perimeter drain.

System 5 showed much lower fecal counts than the flooded system, but the mean value for fecal coliform was considerably higher than the 200 org/100 ml minimum standard (Table 2). High counts of fecal organisms were characteristically obtained from one side of the perimeter drain only (data not shown). Evidence of rodent activity was observed between the disposal field and one side of the drainage system. "Short-circuiting" of effluent through gopher burrows to the perimeter drain appeared to account for these high fecal counts. Next season's monitoring will help determine whether this type of phenomena can be expected to continue where it presently exists and whether other systems will be affected. Reported fecal coliform levels as high as 40,000 org/100 ml in urban storm runoff (13) and seasonally high stream levels resulting from overloaded sewer plant discharges (14) suggest that observed values for indicator organisms from Systems 5 and 8 are not alarmingly high.

Drainage water from System 9 had very low mean values for the observed parameters (Table 5-2). These results and those from System 6 indicate that a 10 ft setback and 4 ft minimum perimeter drain depth provide adequate zones of unsaturated soil for filtration and treatment of effluent. Septic tank effluent was uniformly distributed throughout the disposal field of System 9 via a low pressure piping system using small diameter (2 in.) pipe. Pressure distribution may have been a contributing factor in the good overall performance of the system. A more significant factor, however, was probably dilution of effluent from the large volume of groundwater flowing through this regional discharge area. These conditions were not present at the other sites studied, where seasonal groundwater with relatively low flow was more common.

CONCLUSIONS

Successful on-site treatment and disposal of septic tank effluent in wet soils was obtained by surrounding disposal field areas with field tile. Tile placed 6 ft deep lowered water tables more effectively than tile placed 4 ft deep, but tiles placed at either depth lowered groundwater sufficiently to prevent saturated soil conditions in disposal trench areas. Vertical groundwater separation distances of as little as 9 in. below disposal trench bottom and a horizontal setback of 10 ft between the perimeter drain and disposal trenches did not result in below standard quality for drainage water. There was no apparent difference in drainage water quality in perimeter drains setback either 10 or 20 ft from disposal trenches. Observations on one system suggested that gravel envelopes in perimeter drains may not be needed when drain tile are installed in soils of the Woodburn series.

Perimeter drains installed around disposal fields did not adversely affect drainage water quality relative to documented environmental problems, such as urban runoff and point source discharges. Impact on receiving streams, road ditches, and other discharge points should be considered, however, outside of rural density areas.

Based on the performance of systems utilizing 4 ft to 6 ft deep perimeter drains, there appears to be good potential for the success of systems designed with shallower (36 in. deep) perimeter drains on close spacings. Pressure distribution of effluent for these systems may be a good design precaution, particularly where coarse textured soils occur. In addition, pressure dosing facilitates incorporation of a narrow trench design, since concern regarding shock loads of effluent is alleviated. Application of this concept may be useful in many situations, but the potential as a cost-saving sand-filter alternative is particularly noteworthy.

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CHAPTER 6

SEEPAGE TRENCHES IN SOILS WITH SLOW AND VERY SLOW PERMEABILITIES

There are over 200,000 acres of fine-textured soils in Oregon with slopes between 3 and 20% (9,10). These soils are slowly and very slowly permeable and exhibit high shrink-swell characteristics on wetting and drying. Standard soil absorption systems are not permitted in these soils under current health codes (2,4) because of a history of failures caused by internal soil movement and percolation rates of 300 minutes/in. or less. Changes in soil moisture content cause movement of soil which disrupts disposal trenches and distribution piping (8). In addition, very slow percolation rates cause ponding of effluent in disposal trenches and surfacing of partially treated sewage during periods of prolonged rainfall.

On-site sewage disposal is rapidly becoming recognized as a long-term and more cost-effective alternative to sewage collection and treatment systems in rural and semirural areas. However, construction of standard on-site sewage disposal systems for new housing and for repair of failing systems is not justified in soil areas where experience has demonstrated that these systems will not function properly. A need, therefore, exists to develop suitable alternatives to allow development of nonagricultural land, not currently suitable for on-site waste disposal, and to repair failing systems that are causing a public health hazard.

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This study was undertaken to determine if either large disposal fields using standard disposal trenches or disposal fields using seepage trenches could be used to overcome limitations of very slow percolation rates and the disruptive action of internal soil movement.

METHODS AND MATERIALS

SITE DESCRIPTION

Nine systems were installed in soils of the Carney series in Jackson County and 6 systems were installed in soils of the Oxbow and Tub series in Grant County. The Carney series (5) consists of moderately well drained, fine textured soils formed in clayey pedisediments derived from volcanic tuffs and breccias. They have high shrink-swell potential and very slow permeability (less than 0.06 in./hr). The Oxbow (7) and Tub (6) series consist of well-drained gravelly and cobbly soils formed in old colluvium and sediments. Surface horizons are moderately fine textured and subsoils are fine textured. These soils have slow permeability (0.20 to 0.06 in./hr). Carney soils occur at elevations of 1200 to 2500 ft on slopes that range between 10 and 20%. Oxbox and Tub soils occur at elevations of 2700 to 3500 ft on slopes that range between 3 and 12%. Annual precipitation ranges from 15 to 25 in. at sites in Jackson County and from 11 to 15 in. at sites in Grant County. Most of the precipitation occurs during the winter and early spring.

SYSTEM DESIGN

Each system consisted of a standard 1000 gallon septic tank, a series of drop structures, and gravity-fed disposal or seepage trenches. Disposal trenches were 2 ft wide and 2 ft deep with 4 in. perforated piping bedded in 12 in. of gravel and covered with 12 in. of native soil.

This design was subsequently modified to use seepage trenches installed 36 to 48 in. deep. Thickness of gravel was 24 in. and thickness of soil backfill was 12 to 24 in. This modification was made to increase the storage capacity, increase the absorptive surface, and increase the hydraulic head in the seepage trench. In addition, deeper excavation resulted in removal of clay to sufficient depth that the hazard of disruption of trenches and distribution piping was eliminated.

System sizes varied from 600 to 3000 ft^2 effective sidewall absorption area. All construction was done during the summer to reduce the hazard of smearing of trench bottoms and sidewalls, but unfortunately it was impossible to eliminate smearing. Meters were installed on water service lines to each residence to record water use.

SYSTEM MONITORING

Water depths in disposal and seepage trenches were monitored only during the wet season (November through May) of 1977-78, 1978-79, 1979-80 and 1980-81. Water use was monitored during this same period.

Performance of each system was evaluated by comparing mean water depth in each trench, during the winter months, with the height of the sidewall absorption area. For example, a system with a mean water depth of 12 in. and a sidewall absorption height of 24 in. (24 in. of gravel filter material in the trench) had a performance of 50% of capacity.

RESULTS

All of the soil absorption systems installed in Grant County functioned below 35% of capacity (Table 1). In addition, there were no surface failures during periods of heavy rainfall.

TABLE 6-1. DISPOSAL TRENCHES(1) IN SOILS WITH SLOW PERMEABILITY

SYSTEM	SIDEWALL ABSORPTION AREA	SEWAGE FLOW	PERFORMANCE	OBSERVATIONS
	(ft^2)	(gpd)	(% Capacity)	(Number)
	(GRANT COUNTY - 15 in. PRECIPITATION OR LESS)			
1	600	106	14	6
2	900	185	17	9
3	900	123	5	7
4	900	158	18	7
5	900	-	33	6
6	1500	-	5	4

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(1) Disposal trenches were 24 in. deep with 12 in. of filter material (gravel).

System performance varied considerably in Jackson County. Systems using 24-in. disposal trenches did not function satisfactorily, but systems with seepage trenches 36 in. deep or more functioned properly. Systems 1, 2, 3, and 4 utilized more than 70% of the system capacity during the wet months (Table 2). System 1 failed more than 75% of this period. The system was repaired in April 1979 when an evapotranspiration absorption bed 6 ft wide, 120 ft long, and 2 ft deep was added below the last disposal trench. The entire system failed again May 10, 1979 and continued to do so until the end of the monitoring period. System 3 failed in January 1980 and March 1980 following periods of heavy rainfall and System 4 failed in

TABLE 6-2. DISPOSAL TRENCHES(1) IN SOILS WITH VERY SLOW PERMEABILITY

SYSTEM	SIDEWALL ABSORPTION AREA (ft^2)	SEWAGE FLOW (gpd)	PERFORMANCE (% Capacity)	OBSERVATIONS (Number)
	JACKSON COUNTY 15 in. to 25 in. PRECIPITATION			
1	1600	239	93(2)	9
2	900	126	89	13
3	2025	175	72(3)	14
4	1600	162	73(4)	20
5	1200	198	54	23

(1) Disposal trenches were 24 in. deep with 12 in. of filter material (gravel).

(2) System 1 failed 75% of the time.

(3) System 3 failed during a period of heavy rainfall in January, 1980, and March, 1980.

(4) System 4 failed during periods of heavy rainfall in December, 1977, March, 1980 and April, 1981.

December 1977, March 1980, and April 1981 following periods of heavy rainfall. System 2 performed at 89% of capacity during the wet period but no surface failures occurred.

Soil absorption systems using seepage trenches 36 in. deep or more functioned satisfactorily during the wet winter months with no surface failures. Systems 1, 3, and 4 used less than 5% of system capacity (Table 3). System 2 used 63% of system capacity.

TABLE 6-3. SEEPAGES TRENCHES(1) IN SOILS WITH VERY SLOW PERMEABILITY

SYSTEM	SIDEWALL ABSORPTION AREA	SEWAGE FLOW	PERFORMANCE	OBSERVATIONS
	(ft^2)	(gpd)	(% Capacity)	(Number)
	(JACKSON COUNTY 15 in. - 25 in. PRECIPITATION			
1	3000	136	5	24
2	2400	186	63	26
3	1800	31	5	6
4	1200	150	5	6

(1) Trench depth varied from 36 to 48 in. with 24 in. of filter material (gravel). System 2 had 12 in. of soil backfill, and Systems 1, 3 and 4 had 24 in. of soil backfill.

DISCUSSION

Satisfactory performance of soil absorption systems in Grant County (Table 1) was attributed to soil absorption system size, low annual precipitation, and soil permeability rates (6,7) sufficient to accept effluent without surfacing. Systems were sized at 0.5 gal/ft.^{2} of sidewall absorption area per day, but measured sewage loading rates (Table 1) were well below this. Annual precipitation was less than 15 in., and did not interfere with the soils capacity to absorb effluent.

Failures in Jackson County were caused mainly by infiltration of surface water, very slow soil permeability rates (5), and use of disposal trenches too shallow to establish equilibrium hydraulic heads. System 2 (Table 2) was monitored during December, 1977 and January and February, 1978 prior to completion of the house and use of the septic tank and soil absorption system. Observation of monitoring wells showed that 97% (data not shown) of this system was filled with water. The first disposal trench contained 11 in. of water, trench 2 contained 12 in. of water, and the last trench had water standing 4 in. from the soil surface. This system was placed into use in March of 1978 and was near failure during March, November, and December of 1978; February, March, April, November, and December 1979; February, March, April, November, and December 1980; and February, March, and April 1981. System 3 and System 4 also had a history of failure as did System 1 in spite of enlargement of this system in April, 1979. System 5 was near failure during December, 1977; January, February, and March, 1978;

and February 1979, but functioned satisfactorily during the remainder of the monitoring period using only 4 of the 6 disposal trenches.

All of these failures were associated with periods of heavy rainfall when runoff water infiltrated into disposal trenches. These soils were dry when disposal trenches were installed. Consequently, much of the soil was in the form of extremely hard clods. When disposal trenches were backfilled with this cloddy soil material, a rough, porous backfill was formed over each disposal trench. Surface runoff, from the first heavy rains, rapidly infiltrated through this backfill and raised water levels in all disposal trenches. The backfill subsequently settled and formed depressional areas on the soil surface temporarily ponding water which ultimately infiltrated into disposal trenches. Disposal trenches were too shallow to allow water levels to rise sufficiently to drive the effluent through the very slowly permeable soils before surface failures occurred.

Soil absorption systems using seepage trenches 36 in. deep or more functioned satisfactorily because of a combination of increased absorptive surface, increased hydraulic head, mechanical compaction of trench backfill, and in some systems more rapid soil permeability rates with depth. Seepage trenches theoretically can function properly in very slowly permeable soils if the absorptive area is adequately large (1). Seepage trenches had twice as much sidewall absorptive surface as disposal trenches. The effluent storage capacity was also doubled. In addition, trenches were deep enough to allow higher hydraulic gradients. Observation of System 2 (Table 3, data not shown) showed that about 21 in. of effluent occurred in the first trench and about 13 in. of water occurred in the lower three trenches. Effluent had to rise to 24 in. in this system to flow through the drop box into the next lowest line. Inspection of drop boxes showed that only the first seepage trench of this system contained sewage. Surface water infiltrated into the lower trenches of the system during the first heavy rains the same way it did into systems using disposal trenches because the backfill was loose and cloddy and only 12 in. thick. Water and sewage percolated through these soils very slowly because of very slow permeability rates. However, as sewage levels rose in the first trench, the effluent acceptance rate increased in response to the increased hydraulic gradient (3) and equilibrium was apparently reached with a hydraulic head of about 21 in. Sewage remained at this level in the first trench and water remained at about 12 to 15 in. in the lower trenches during the wet winter season. Water levels dropped and all but the first trench became desaturated during the dry summer season.

Systems 1, 3, and 4 (Table 3) were dry most of the time, except for the first line. This was true even in the winter season, during and immediately after periods of intense and prolonged rainfall. Infiltration was minimized by mounding backfill over the seepage trenches and mechanically compacting to a final thickness of 24 in. In addition, trenches in Systems 1 and 4 were excavated into calcareous substratum that was more permeable. System 3 had a very low daily sewage flow.

CONCLUSIONS

Soil absorption systems consisting of 24 in. deep disposal trenches installed in fine-textured soils functioned properly in Grant County where annual precipitation was 15 in. or less. Twenty-four in. disposal trenches were not satisfactory in Jackson County where rainfall exceeded 15 in. Surface failures were common during periods of prolonged rainfall.

Seepage trenches 36 in. deep or more functioned satisfactorily where annual precipitation did not exceed 25 in. Satisfactory performance was attributed to a combination of increased absorptive surface, increased hydraulic head in trenches, proper trench backfill, and in some systems more permeable soil with depth, or very low daily sewage flow.

None of the disposal trenches and some of the seepage trenches were not backfilled properly because of the hard cloddy nature of the dry clay soils. As a result, infiltration of surface water was a problem in these systems. Soil backfill should be mounded over trenches and mechanically compacted, and diversion ditches should be constructed above each system to intercept surface waters.

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CHAPTER 7

SEEPAGE TRENCHES ON STEEP SLOPES

Greater then 350,000 acres of deep, well-drained soils with slopes exceeding 25% occur in Oregon, principally west of the Cascades. Standard disposal field construction was prohibited on these sites in the past, due to concern for effluent seepage downslope. Practical considerations regarding equipment operation and construction under these conditions discouraged regulators from considering whether on-site disposal was actually feasible.

Slope steepness, however, does not necessarily limit satisfactory performance of septic tank effluent disposal fields. Where other site conditions such as soil depth, permeability, and drainage are favorable, deep disposal trenches (seepage trenches) may provide adequate treatment and disposal. This study was conducted to determine if seepage trenches would function satisfactorily when installed in suitable soils on slopes in excess of 25%.

METHODS

Four seepage trench disposal fields were installed on sites with slopes ranging from 30 to 45%. Soils at each site had a minimum 60 in. effective depth, were well to moderately well drained, and occurred on planar or convex slopes. Seepage trench design (Figure 7-1) consisted of 2 ft wide, level bottom trenches installed 30 to 36 in. deep. An 18 in. gravel envelope was placed in the trench bottom with a 4 in. PVC distribution

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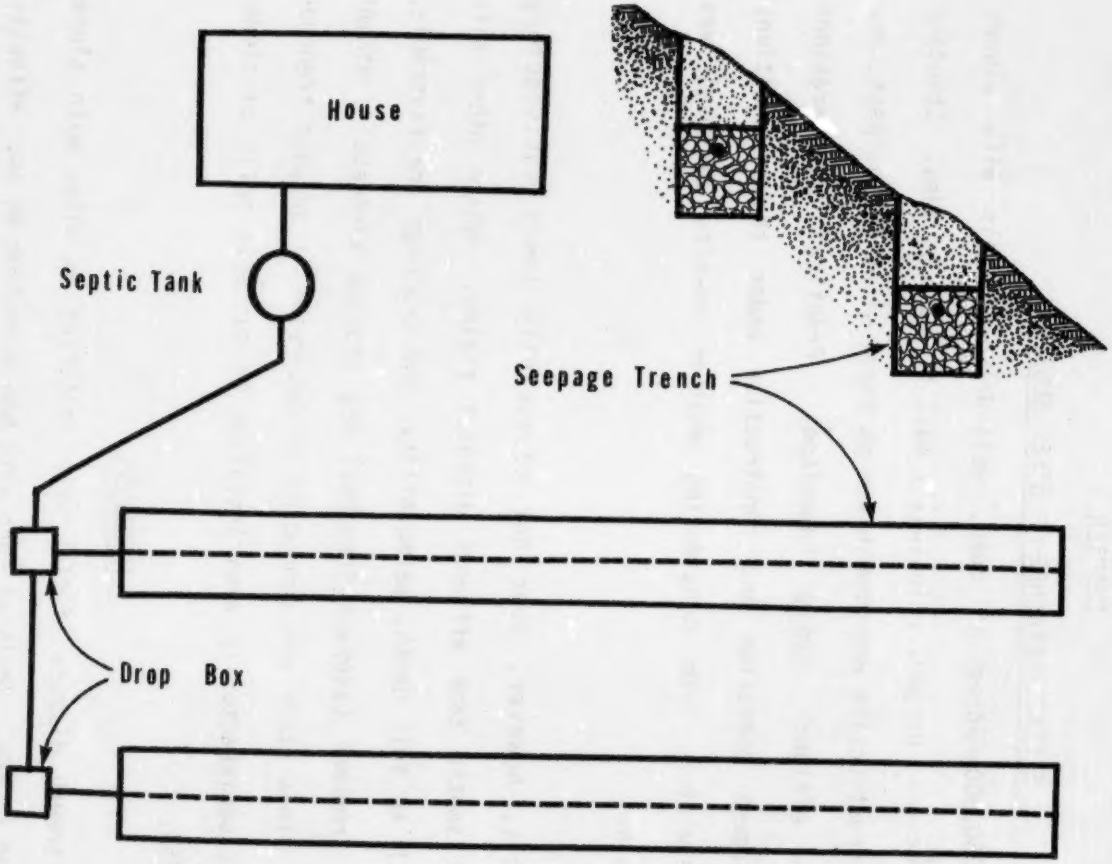
House
Septic Tank
Seepage Trench
Drop Box

FIGURE 7-1. STEEP SLOPE SYSTEM PLAN AND DETAIL OF SEEPAGE TRENCH

pipe located in the upper 6 in. Hand labor was required to varying degrees in trench excavation, gravel placement, and backfilling due to equipment operating limitations. Three to four hundred linear ft of seepage trench were installed per system providing up to 1200 ft^2 of effective sidewall seepage area. Systems were conservatively oversized to alleviate concern about performance.

RESULTS AND DISCUSSION

Seepage trench disposal fields installed on slopes up to 45% performed satisfactorily (Table 7-1). The performance rating listed in the table is based on observed in-trench liquid levels. The percentages were based on the amount of sidewall seepage area being utilized. The data indicated that slope steepness in itself was not a limitation to successful treatment and disposal of effluent. In addition, no seepage or surfacing of effluent occurred downslope in any of the systems. Since other site and soil characteristics were favorable, this was not unexpected.

Calculated performance ratings and monitoring observations suggested that these systems were greatly oversized. Current Oregon Rules for on-site waste disposal require a minimum of 225 linear ft of disposal trench (75 ft/150 gal sewage) with these soil conditions with no slope limitation. Seepage trenches with 50% greater effective seepage area (18 in. gravel envelope vs. 12 in.) and a smaller disposal field on the order of 150 linear ft (450 ft^2) appears reasonable. The smaller system would reduce construction costs particularly where hand labor is involved.

TABLE 7-1. STEEP SLOPE SYSTEMS

SYSTEM	SIZE (ft^2)	FLOW (gpd)	PERFORMANCE (% capacity)
1. Melcher	900	131	0
2. Bergstrom	1080	122	0
3. Bantilan	--	138	20
4. Nelson	1200	300	6

CONCLUSION

Seepage trenches functioned satisfactorily on slopes up to 45%. All of the disposal fields were significantly larger than necessary for satisfactory performance. A minimum effective soil depth of 60 in. was not a necessary criteria for system success. No surfacing of effluent occurred downslope from any systems. Operation of excavating equipment on slopes over 30% is difficult and may be impossible on some sites.

Future experimental systems on steep slopes will be installed where minimum effective soil depth is 42 in. Seepage trenches will be sized at 50 linear ft per 150 gal projected daily flow.

CHAPTER 8

DISPOSAL TRENCHES IN SOIL SHALLOW TO WEATHERED AND FRACTURED BEDROCK

Shallow soil depth is a common site limitation for on-site sewage disposal systems in Oregon. The primary concern was that septic tank effluent would not be adequately treated and absorbed where shallow soil occurred. The current Oregon on-site sewage disposal rules required a 30 in. minimum effective soil depth.

Weathered bedrock or saprolite often has desirable characteristics for treatment and disposal of septic tank effluent. Although structural properties are different than soil and organic matter contents are lower, permeability characteristics are often favorable. The introduction of nutrients from the household waste stream is likely to stimulate biological activity and subsequent treatment in this medium much the same as takes place in soil material.

Several million acres of soils shallow to weathered bedrock exist throughout the state. These areas are of special interest where they occur in foothills adjacent to agricultural land. Since preservation of deeper, more arable land is a designated land use goal, development and use of shallow soils for on-site sewage disposal is increasingly attractive.

An additional consideration is the validity of denying shallow soil sites from a public health standpoint. Characteristically, shallow soils in

Western Oregon are associated with upland landscape positions. Usable groundwater is typically 100 to 300 ft deep so concern regarding lack of treatment by permeable weathered rock may not be justified. Variable topography often limits development density, and this factor may further diminish valid concern regarding groundwater protection.

This study was initiated to evaluate performance of disposal fields in soils shallow to weathered bedrock.

METHODS

Seven on-site disposal systems were installed on upland sites with shallow effective soil depth in Western Oregon. Typically soils were classified as Philomath or Dixonville series in Soil Conservation Service surveys. Effective soil depth varied from 29 in. to as little as 12 in., with underlying weathered bedrock of volcanic or sedimentary origin.

Soil absorption fields consisted of gravity-fed disposal trenches 2 ft deep and 2 ft wide with 4 in. perforated piping bedded in 12 in. of gravel (Figure 8-1). Systems were conservatively oversized with up to 600 linear ft of disposal field being installed to satisfy initial concerns regarding permeability. (At the time these systems were designed and installed, on-site permits were commonly denied based on the assumption that the weathered substratum was restrictive or impermeable.)

An additional system was installed in Malheur County in Eastern Oregon where rainfall is less than 10 in. per year. Effective soil depth was

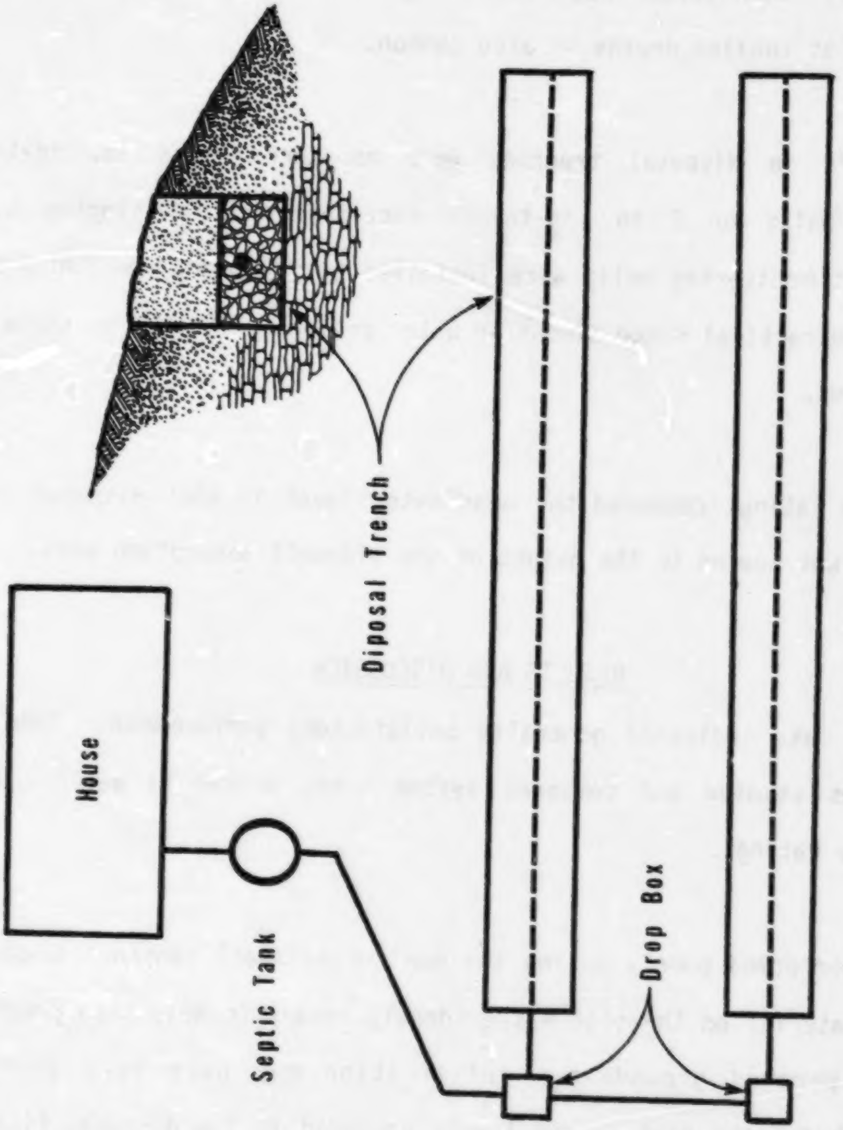
House
Septic Tank
Drop Box
Diposal Trench

FIGURE 8-1. SAPROLITE SYSTEM PLAN AND DETAIL OF DISPOSAL TRENCH

limited to 20 in. by a duripan. The pan was fractured during trench construction. Semi-consolidated bedrock (unweathered due to arid climatic conditions) at shallow depths is also common.

Water levels in disposal trenches were monitored in 4 in. in-trench monitoring wells or 2 in. in-trench piezometers. On sloping sites, downgradient monitoring wells were installed but sampling was found to be generally impractical since almost no water collected in them on these well drained sites.

Performance ratings compared the mean water level in each disposal trench during the wet season to the height of the sidewall absorption area.

RESULTS AND DISCUSSION

Monitoring data indicated generally satisfactory performance. Table 8-1 lists sites studied and compares system size, household water use and performance ratings.

System 6 performed poorly during the monitoring (wet) season. Underlying geologic material on the site was evidently less permeable than predicted. Seasonal perched groundwater infiltration may have been partially responsible for the high liquid levels recorded in the disposal field. A groundwater interceptor was installed upslope, but further measures may be needed. Four out of the 6 disposal trenches were dry or nearly dry 9 months of the year. No water supplies or property are threatened downgradient on this site so public health effects were not a concern.

TABLE 8-1. PERFORMANCE OF DISPOSAL TRENCHES IN SOILS SHALLOW TO WEATHERED BEDROCK (SAPROLITE).

SYSTEM	DISPOSAL FIELD SIZE (ft^2 sidewall area)	WATER USE (gal/day) 79-80	WATER USE (gal/day) 80-81	PERFORMANCE (% capacity) 79-80	PERFORMANCE (% capacity) 80-81
1. (Cameron)	1200	- - -		35	
2. (Gibbs)	1200	175	242	32	40
3. (Liming)	1280	298	94	21	8
4. (Jager)	1210	247	166	19	14
5. (Byers)	800	185	-	0	0
6. (Escalera)	900	196	-	89	88
7. (Eager)	1208	144	189	0	7
Mean	1037	183	179	25	26

Other systems performed at much less than 50% of capacity during the monitoring season suggesting that they were larger than necessary. Groundwater was not encountered in any downgradient monitoring wells. This suggested that net downward movement of effluent occurred under the disposal field rather than downslope with the exception of System 6. Extreme depth of domestic wells in the area and sparse population density suggested that groundwater sampling and concern about groundwater contamination were unwarranted.

No water was observed in disposal trenches in the system in Eastern Oregon (data not shown). Although this system was installed in subsoil that was slowly permeable, the lack of seasonal moisture indicated that household wastewater constituted the only source of hydraulic loading. This system was evidently larger than necessary with 300 linear ft of disposal trench. However, the conservative size may have acted as a buffer against shock loading and insured longer system life.

CONCLUSIONS AND RECOMMENDATIONS

Shallow effective soil depth is not an essential limiting factor for on-site sewage disposal. Weathered bedrock allowed effective absorption and disposal of effluent in Western Oregon upland soils such as Dixonville and Philomath. Effective treatment or attenuation of effluent components was probable but difficult to verify due to sampling limitations. Depth of groundwater and low development density suggested that groundwater contamination was not a concern.

Effective soil depth was even less a concern in arid counties in Eastern Oregon. Slow substratum permeability was offset by adequate sizing of disposal fields.

Rules should be revised to allow installation of disposal trenches in well drained soils that are shallow to weathered bedrock (saprolite) and duripans where other site characteristics are favorable.

CHAPTER 9

PRESSURE DISTRIBUTION SYSTEMS IN SOILS WITH SHALLOW GROUNDWATER

Conventionally designed septic tank effluent disposal fields rely on a zone of unsaturated aerobic soil to provide treatment and filtration. Where shallow groundwater occurs the depth of unsaturated soil beneath disposal field trenches may be inadequate. This is particularly true in soils with moderate to very rapid permeability where gravity distribution methods may create effluent saturation zones in the first few feet of disposal trenches.

A possible means of preventing bacterial contamination of groundwater by saturated flow ("shortcircuiting") of incompletely treated septic tank effluent, may be through controlling effluent dosing rates and providing uniform effluent distribution throughout the entire disposal field using a low pressure distribution system. Effluent pumped through small diameter plastic piping perforated by 1/8 in. orifices can be dosed uniformly throughout an entire soil absorption system. The level of effluent treatment and filtration should vary with the thickness and texture of unsaturated soil above groundwater.

The objective of this study was to test several vertical separation distances between the bottom of disposal trenches and groundwater where pressure distribution systems were installed. The impact of effluent on groundwater quality was monitored and assessed. Proper sizing, design, and overall performance of low pressure distribution systems were chacterized.

METHODS

Effluent disposal systems fed by low pressure distribution were constructed at 6 sites. Soil characteristics at 3 system installation sites corresponded with the broad textural catagory defined in DEQ On-Site Sewage Disposal Rules as Soil Group A (sand, loamy sand, and sandy loam). These systems were constructed in Klamath and Jackson counties. System design (Figure 9-1) consisted of 240 linear ft of 2 x 2 ft disposal trench with 2 in. diameter pressure distribution piping bedded in 12 in. of gravel.

Three additional systems were installed at sites with soil corresponding to Soil Group B (silt loam, loam, and clay loam) in Union and Jackson Counties to assess differences in treatment and filtration through finer textured material. Systems were similar to those installed in coarser soils.

Total and fecal coliform, nitrate-nitrogen and groundwater levels were monitored via shallow well groundwater sampling upgradient and downgradient from the systems. Samples were taken December through April 1980-81. One of the 3 systems for each soil group was surrounded by a perimeter drain (see Section C for design specifications) which served a dual purpose of controlling groundwater level and insuring capture of effluent contaminants which could enter the saturated zone.

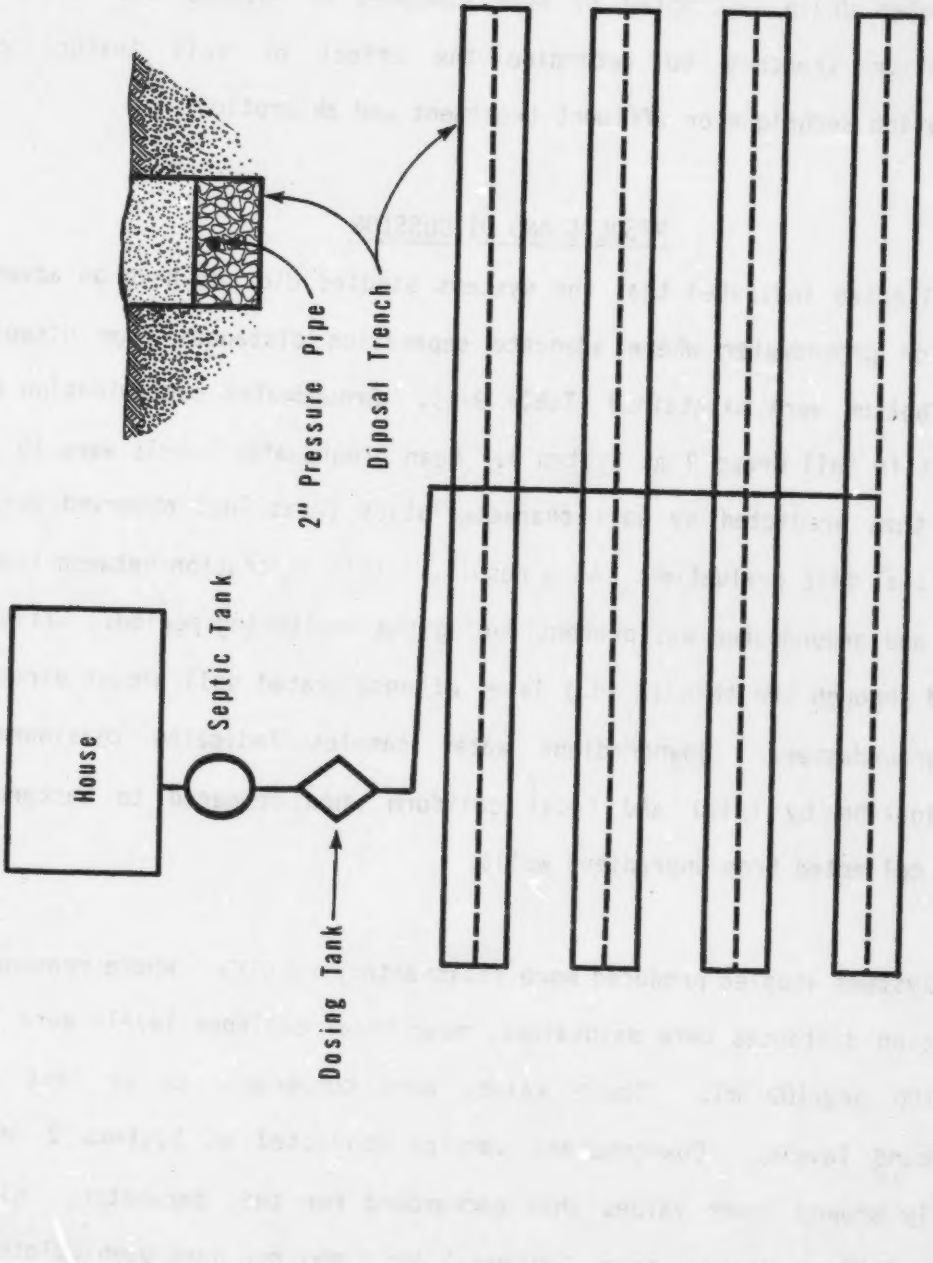
House
Septic Tank
Dosing Tank
2" Pressure Pipe
Diposal Trench

FIGURE 9-1. LOW PRESSURE DISTRIBUTION SYSTEM PLAN AND DETAIL OF DISPOSAL TRENCH

The need for pressure distribution to achieve equal distribution and acceptable treatment levels in medium textured (Soil Group B) soil was considered. Results from a system with gravity fed trenches surrounded by a perimeter drain (Chapter 5) were compared to systems with pressure distribution trenches to determine the effect of soil texture and distribution technique on effluent treatment and absorption.

RESULTS AND DISCUSSION

Data collected indicated that the systems studied did not have an adverse impact on groundwater where adequate separation distances from disposal trench bottom were maintained (Table 9-1). Groundwater contamination was apparent in Soil Group B at System 4. Mean groundwater levels were 10 in. higher than predicted by soil characteristics (mottling) observed during the initial site evaluation. As a result, little separation between trench bottom and groundwater was present during the monitoring period. Effluent drained through the thin (2 in.) layer of unsaturated soil almost directly into groundwater. Downgradient water samples indicated considerable contamination by total and fecal coliform when compared to background levels collected from upgradient wells.

Other systems studied produced more satisfactory results. Where reasonable separation distances were maintained, mean fecal coliform levels were less than 100 org/100 ml. These values were comparable to or less than background levels. Downgradient samples collected at Systems 2 and 3 actually showed lower values than background for this parameter. Higher total coliform levels from Systems 1 and 5 may not have been related to effluent disposal fields. Lack of high corresponding fecal coliform levels for these systems suggested total coliform contamination could have resulted from some other source such as animal manure.

Table 9-1. MEAN BACKGROUND AND DOWNGRADIENT GROUNDWATER QUALITY FOR PRESSURIZED EFFLUENT DISPOSAL SYSTEMS.

System	Separation Distance (inches)	NH_4-N	NO_3-N	Total C	Fecal C	#Obs.
		mg/l(1)		#Org/100ml(2)		
		Soil Group A				
1 (a)	29	16.3	0.2	10,488	100	2
(b)		0.5	1.1	177	17	5
2 (a)	39	2.3	0.5	1,000	22	4
(b)		0.1	14.6	1,000	100	4
3 (a)	48	0.1	1.8	149	10	6
(b)		0.1	1.8	100	12.5	5
		Soil Group B				
4 (a)	2		0.02	6,468	1229	4
(b)			0.03	234	17	4
5 (a)	24		0.6	2,928	70.6	5
(b)			1.2	246	61.8	5
6 (a)	32		0.9	93	6	3
(b)						
7 (a)	15		0.9	11,441	38.9	6
(b)			1.0	7,032	67.9	6

FOOTNOTES:

(a) Downgradient,
(b) Upgradient
(1) Arithmetic mean
(2) Geometric mean

Data for Systems 2 and 3 in Soil Group A indicated no groundwater impact where a 39 in. to 48 in. separation between trenches and groundwater was maintained. These results suggested that low pressure disposal systems offer an advantage in Soil Group A where gravity systems might create local saturated flow and subsequent groundwater contamination.

Systems 5 and 6 in Soil Group B performed well when only 24 in. and 32 in., respectively, separation distances between trenches and groundwater were maintained. System 6 had lower mean fecal coliform levels than background for any of the other systems. Groundwater dilution due to a relatively high flow rate through the area may partially account for observed values. Nonetheless, performance indicated that system installation, where these site conditions exist, was feasible.

Since permeabilities in Soil Group B are likely to be slower, it is conceivable that equal distribution throughout the disposal trenches could be achieved by gravity flow. Data for performance of conventional gravity distribution trenches with respect to required separation distances are not available. The assumption that 4 ft of unsaturated soil is necessary for effluent treatment and filtration is made in Oregon on-site sewage disposal rules.

Comparison of data from pressurized systems with data from System 7 (Table 9-1) which had gravity distribution, indicated pressure distribution may not be necessary for adequate system performance. Even though separation distances were less (15 in.) for System 7, fecal coliform levels were comparable to those obtained from pressurized systems installed in similar soils. This comparison was not anticipated at the onset of the program, so similar relationships for Soil Group A were not included in the experimental design. However, experience with groundwater contamination from gravity systems in coarse textured soils suggested that pressure distribution was probably more effective.

CONCLUSIONS AND RECOMMENDATIONS

Pressurized effluent disposal fields offered an advantage in obtaining equal distribution of effluent in moderately coarse to coarse textured soils where potential groundwater contamination was of concern. Controlled application rates and regulated dosing cycles prevented rapid saturated flow into groundwater from localized areas in the disposal field. The resulting treatment and filtration of effluent created little or no groundwater contamination where a separation distance of at least 30 in. was maintained.

The advantage of pressure distribution in medium and finer textured soil material (Soil Group B) was less obvious. Where well developed soil profiles occurred, pressure distribution might prevent shortcircuiting of effluent through macropores and structural voids. Where soil structure was more weakly expressed or undeveloped, equal distribution may take place in a gravity flow system. In addition, retention and treatment of potential contaminants in the unsaturated zone would be greater for medium and fine textured soil due to relatively slow hydraulic conductivity regardless of distribution technique.

CHAPTER 10

EVAPOTRANSPIRATION SYSTEMS

There are several million acres of soil in semi arid and arid regions of Central and Eastern Oregon. These soils are not suitable for installation of standard subsurface treatment and disposal systems because of shallow depth, very slow permeability, or high groundwater tables. Non-discharging evapotranspiration (ET) beds appeared to be an appealing alternative. This study was undertaken to determine if evapotranspiration beds could be used to overcome these soil limitations.

METHODS

Sixteen Armon Systems of Oregon, Inc. (evapotranspiration beds) were installed in Jackson County and one non-Armon ET system was installed in Baker County. Potential evapotranspiration exceeds precipitation by more than 10 in. in areas of these 2 counties where ET systems were installed.

The Armon ET system consisted of a uniquely constructed downflowing two-compartment fiberglass septic tank. Effluent discharged through the bottom and flowed up through gravel surrounding the outside of the tank into the ET bed lined with a 4 mil plastic liner. The tank was located in the center of the bed. The ET bed was 36 in. deep and contained 12 in. of 3/4 to 2-1/2 in. drainfield rock covered by 24 in. of sand. The beds were crowned with a slope of 3%. Bed sizes varied from 1200 to 3000 ft^2.

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One monitoring well was located in the center of the bed adjacent to the septic tank. Two underdrains were installed beneath the ET bed and connected in a V-pattern to a monitoring well located outside of the bed.

The non-Armon ET bed was 30 in. deep and contained one ft of 3/4 to 2-1/2 in. drain-rock covered by 18 in. of silt loam. The ET bed was lined with a 20 mil factory welded PVC liner. Bed size was 7500 ft^2 of surface area. One monitoring well was located inside the bed and one was located outside the bed and connected to an underdrain to check the integrity of the liner.

Water levels, sewage flow, fecal coliform, and chloride were monitored once per month during the winter and spring months from January 1977 to May 1979.

RESULTS AND DISCUSSION

Thirteen Armon ET beds in Jackson County showed evidence of leakage. High fecal coliform counts occurred in monitoring wells immediately outside of the beds. Chloride concentration failed to build up inside of the beds, but was inversely correlated to rainfall. Water levels in the beds fluctuated in response to precipitation and free water in the surrounding soils. Most of these beds were installed in well and moderately well drained soils and water levels dropped rapidly inside and outside of beds when periods of heavy precipitation terminated. As a result, leakage of effluent did not create a potential health hazard because it was absorbed and treated in surrounding soil.

One system, installed in poorly drained soil, was inundated when rising groundwater seeped into the bed. This occurred before the house was completed and connected to the system. A community sewer was extended and connected to this house in 1980.

Another ET bed was installed in an impervious sandstone. The bed filled up and overflowed after 4 months of use.

The 7500 ft^2 non-Armon ET system in Baker County functioned properly with no evidence of leakage.

CONCLUSIONS

Armon Systems of Oregon, Inc. ET systems did not perform satisfactorily in Oregon. The 4 mil plastic liner was of such poor quality that all of the systems leaked untreated effluent out of the bed and into the soil system. This created no potential health hazards in well and moderately well drained soils but was a distinct problem in poorly drained soils. Armon ET beds were much too small to function safely on evapotranspiration. Bed size would have to be increased about 3 times to function successfully in Oregon. As a result, ET systems were dropped from the experimental program in 1979.

Chapter 11

EVAPOTRANSPIRATION ABSORPTION SYSTEMS

There are over 100,000 acres of fine-textured soils in Oregon where annual evapotranspiration exceeds annual precipitation. These soils have permeability rates of less than 0.20 in./hr. Oregon On-site Sewage Disposal Rules do not allow installation of standard soil absorption systems in these soils because of concern for surface failures. Evapotranspiration-Absorption (ETA) beds were installed in these soils to determine if the combination of soil absorption and evapotranspiration would overcome the limitation of slow and very slow permeability and allow an on-site treatment and disposal system to function properly.

METHODS

Evapotranspiration-Absorption systems consisted of a septic tank followed by an unlined seepage bed. Seepage beds were constructed 24 in. deep with 12 in. of gravel and 12 in. of backfill. Texture of the backfill was clay loam or clay. ETA bed size ranged from 1500 to 2880 ft^2 of bottom area. Square or rectangular seepage beds were used on nearly level terrain. These beds were elevated, and contained within soil dikes (Figure 11-1). This allowed placement of systems on shallow soils and prevented infiltration of surface runoff. Long narrow beds were used on sloping sites (Figure 2). These were excavated into the ground. System 4 (Table 11-1) used equal distribution and the remainder of the ETA Beds used serial distribution. Ten ETA beds were installed and effluent levels in each bed

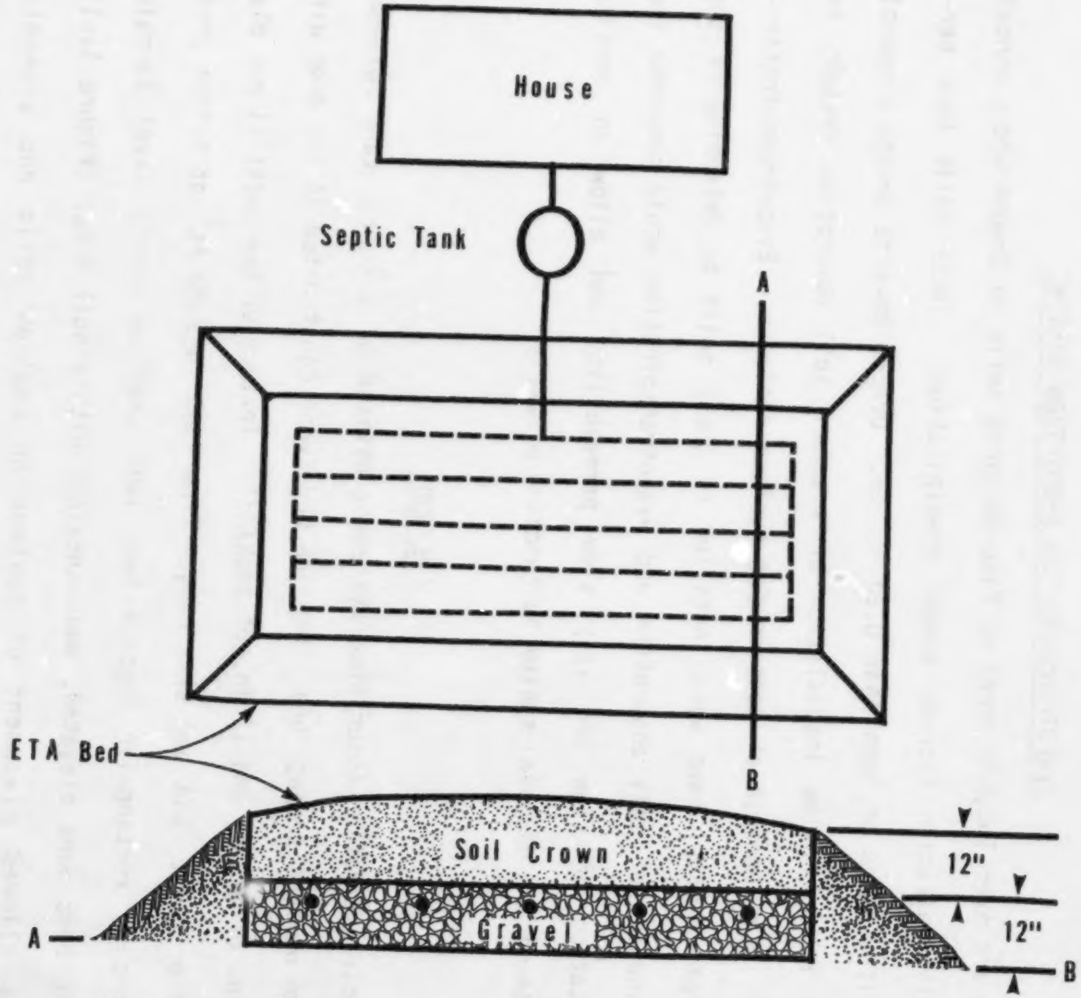
House
Septic Tank
A
B
ETA Bed
Soil Crown
Gravel
A
B
12"
12"

FIGURE 11-1. DIKED EVAPOTRANSPIRATION ABSORPTION SYSTEM PLAN

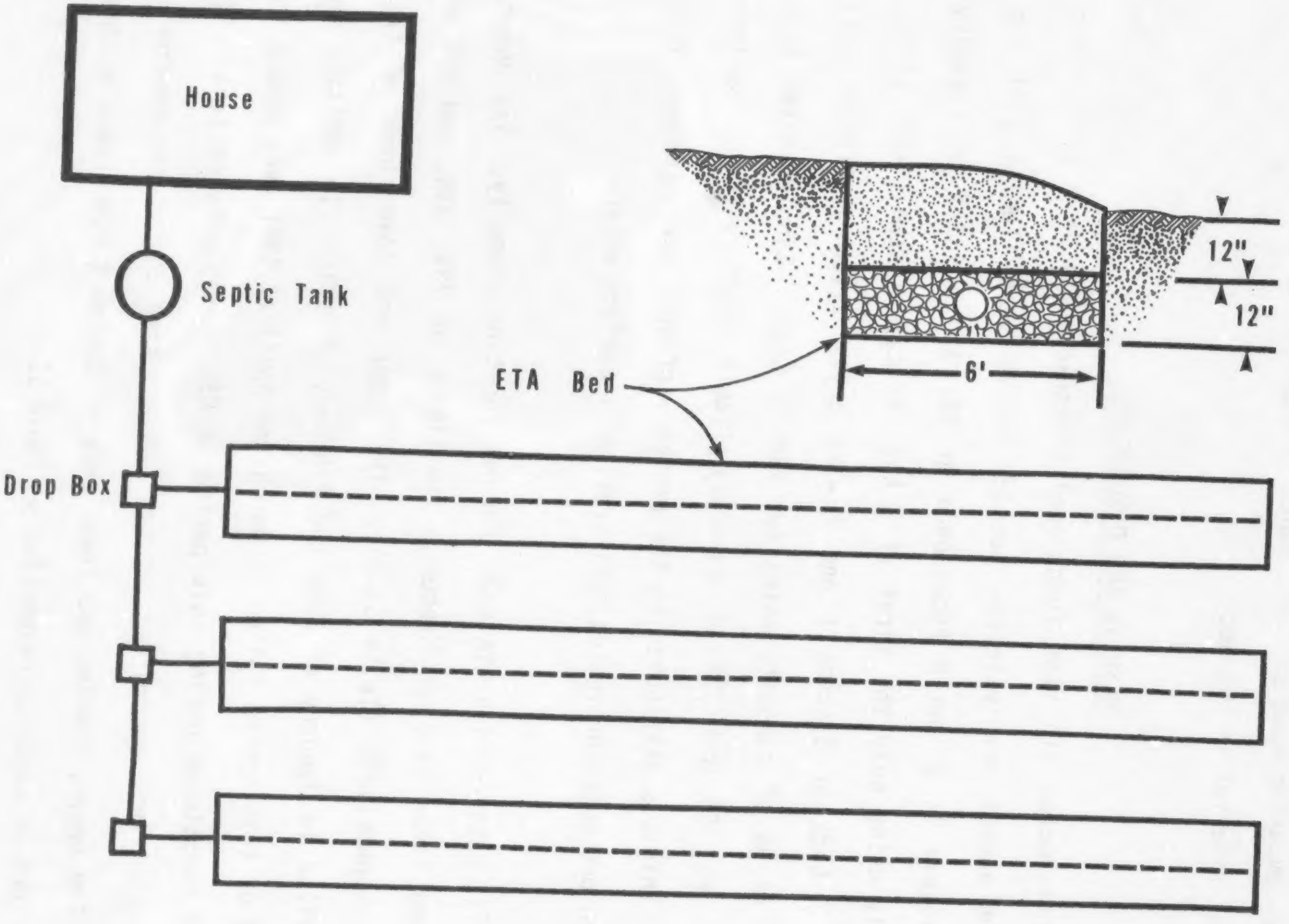
House
Septic Tank
Drop Box
ETA Bed
12"
12"
6'

FIGURE 11-2. SERIAL DISTRIBUTION EVAPOTRANSPIRATION ABSORPTION SYSTEM PLAN

were monitored during the wet season. Performance of each system was evaluated by comparing mean effluent depth in each bed to the height of the gravel filter material in the bed.

RESULTS AND DISCUSSION

Properly constructed ETA beds functioned satisfactorily in fine-textured soils where annual precipitation was 25 in. or less (Tables 11-1 and 11-2). Systems 1, 2 and 3 functioned at 8%, 4%, and 16% of capacity respectively using only the first of 3 beds in each system (Table 11-1). The lower 2 beds of Systems 1 and 2 were dry. System 4 (Table 11-1) functioned at 4% of capacity using two 750 ft^2 beds. Single, diked beds functioned at 75% and 25% of capacity (Table 11-2) with no surface failures. This was attributed to the presence of soil dikes (embankments) around each bed which prevented infiltration of surface water.

Three serial distribution ETA beds did not function properly. The upper, middle, and lower beds of System 8 functioned at 75%, 33%, and 42% of capacity respectively (Table 11-3). The upper and lower beds of this system failed in January of 1980 and February of 1981. In addition the lower bed of this system failed in March and April of 1981 even though the upper bed functioned during this period at 83% of capacity or less. The middle bed of this system did not fail at any time during the monitoring period. The upper, middle, and lower beds of System 9 functioned at 100%, 50%, and 100% of capacity respectively (Table 11-3).

Table 11-1. SERIAL DISTRIBUTION EVAPOTRANSPIRATION-ABSORPTION SYSTEMS

System	Sewage Flow (gpd)	System Size (ft^2)	Performance (% capacity)
	Jackson County - 15 in. to 25 in. Precipitation		
1. Holmes	169	1680 (560)(1)	8
2. Robertson	71	2880 (720)	4
	Union County - 20 in. to 25 in. Precipitation		
3. Rogers	108	2040 (510)	16
	Grant County - 15 in. Precipitation or Less		
4. Kimball(2)	127	1500 (750)	4

(1) The first number is the total surface area (bed bottom area) of the system. The number in parentheses is the surface area of each individual bed.

(2) System 4 used equal distribution to one bed on each side of a distribution box.

Table 11-2. DIKED EVAPOTRANSPIRATION-ABSORPTION SYSTEMS

System	Sewage Flow (gpd)	System Size (ft^2)	Performance (% capacity)
	Jackson County - 15 in. to 25 in. Precipitation		
5. Lake	205	2550	75
6. Pettigrew	125	1900	25
7. Wilson	89	1700	25

Table 11-3. FAILING SERIAL DISTRIBUTION EVAPOTRANSPIRATION-ABSORPTION SYSTEMS

System	Sewage Flow	System Size	Performance		
			Bed 1	Bed 2	Bed 3
	(gpd)	(ft^2)	-- % Capacity --		
8. Fletcher	143	1890 (630)(1)	75	33	42
9. Shambaugh	145	2550 (830)	100	50	100
10. Smith	108	1800 (600)	50	58	100

(1) The first number is the total surface area (bed bottom area) of the system. The number in parentheses is the surface area of each individual bed.

The upper and lower beds of this system were saturated with surface water most of the winter and early spring months. The middle bed was at near capacity in February, 1979; November, 1979; January, 1980; and April, 1980; but was at less than 35% of capacity during the remainder of the monitoring period. The upper, middle and lower beds of System 10 functioned at 50%, 58%, and 100% of capacity respectively (Table 11-3). Surface water infiltrated into System 10 and resulted in 7 in. of water in the middle bed and 16 in. of water in the lower bed during the winter and spring months. Water seeped from the bottom bed of this system during rain storms in December, 1979; January, 1980; February, 1980; and March, 1980. This seepage occurred even though the middle bed contained less than 10 in. of water and the top bed contained less than 7 in. of sewage (data not shown). A surface diversion ditch was constructed above System 10 during the summer of 1980 and no seepage occurred during the winter wet season of 1980-81.

System 8 (Table 11-3) failed mainly because beds were not installed level and drop structures were either installed improperly or the shrinking and swelling of the clay soil disrupted the drop structures so they did not function properly. Infiltration of surface water was also a problem because an adequate surface water diversion ditch was not constructed. In addition, monitoring data was erratic (2 wells in the same bed showed water level variations of 13 in.) because of improper installation of monitoring wells. System 9 (Table 11-3) was installed in a somewhat poorly drained soil that was not suitable for an Evapotranspiration-Absorption bed. A permit was issued for this system prior to adoption of site selection criteria January, 1978, limiting ETA construction to sites with well and moderately-well drained soils. An inadequate surface water diversion ditch also allowed water to infiltrate into the upper and lower beds resulting in seepage during most of the winter and early spring months. System 10 failed because of infiltration of surface water. This problem was corrected by construction of a surface water diversion ditch.

High water levels in ETA beds and seepage failures were associated with the winter wet season. Water levels rose rapidly and surface failures occurred in response to periods of heavy rainfall. Precipitation on the surface of ETA beds and infiltration of surface water exceeded storage capacity in some beds and surface failures resulted. However, most ETA beds functioned properly during the wet winter months even though precipitation exceeded potential evapotranspiration by as much as 8.7 in. (Agricultural Experiment Station Special Report 150, 1963). At no time were water levels high enough in the gravel portions of beds in

Systems 1, 2, 3 and 4 (Table 11-1) and Systems 5, 6 and 7 (Table 11-2) to come in contact with the soil backfill. In addition, there was no evidence of salt accumulation on the surface of any ETA Bed. These observations suggest that very little evaporation and transpiration took place and that ETA Beds functioned almost entirely as soil absorption beds.

CONCLUSIONS

Properly designed and constructed ETA beds functioned satisfactorily in suitable soils in areas where annual precipitation was 25 in. or less.

Infiltration of surface water caused failure of 3 serial-distribution ETA beds but was not a problem in diked systems. Poor construction of ETA beds, drop structure instability, and ineffective diversion ditches were contributing factors.

Somewhat poorly drained soils were not suitable for installation of ETA systems.

ETA beds functioned almost entirely as soil absorption beds with little or no evapotranspiration.

Seepage trenches were a better alternative for fine textured soils because they functioned better, were easier to construct, and used less than half as much filter material (gravel). In addition, seepage trenches maximized absorption and minimized infiltration because they had a smaller ratio of surface area to absorptive surface.

CHAPTER 12

MOUND SYSTEMS

There are more than 1,000,000 acres of soils in Oregon on plane or convex slopes of 12% or less (1) which are too shallow to fragipans, claypans, hardpans, saprolite, bedrock, or groundwater to permit installation of standard septic-tank soil absorption systems under Oregon Administrative Rules (2). Three mounds were installed in somewhat poorly drained soils in the north part of the Willamette Valley during 1976 and 1977 to determine if they could adequately treat and dispose of septic tank effluent during the winter wet season. A fourth mound was installed on a hillcrest in Southwestern Oregon in mid 1976 to determine if septic tank effluent would receive adequate treatment before absorption into soils shallow to metamorphosed sandstone.

METHODS

MOUND DESIGN

Mound systems consisted of a standard septic tank, dosing tank with submersible effluent pump and mercury float switches, and a pressure distribution system located in a soil crowned medium sand fill. Oregon mounds were patterned after mounds in Wisconsin (3, 4) using design criteria in Table 1. The sand treatment medium was at least 25% medium sand with a diameter of 0.25 to 0.5 mm and 25% or less with a diameter finer than 0.25 mm. Because of the pronounced winter wet season (5) in Northwestern Oregon (60% of Western Oregon's precipitation falls between November and April), Bouma (6) and Converse (7) recommended the placement of at least 30 in. of medium sand fill below mound pressure distributon trenches or beds.

TABLE 12-1. MOUND DESIGN CRITERIA[1]

Surface Area	366 ft^2
Treatment Media	Medium Sand 25% 0.25-0.5 mm $<$25% $<$ 0.25 mm
Media Depth	30 in. - where annual ppt. 35 in./yr. 24 in. - where annual ppt. 35 in./yr.
Maximum Design Loading Rate[2]	1.23 gal/ft^2/d
No. Times Effluent Filtered Through Treatment Sand	1
Dosing Frequency	2-5 times/day
Dosing Rate	0.25 - 0.6 gal/ft^2/dose
Dose Volume	90 - 225 gal/dose
Dose Controls	Volumetric; mercury float switches
Media Surface Protected With Soil Cover	Yes

---

[1] Features shown apply to a mound designed to process up to 450 gal septic tank effluent per day.

[2] Based on pressure distribution bed or trench bottom area only.

Greater fill depth was recommended to provide some assurance that the distance separating mound pressure distribution systems and high groundwater tables would be sufficient to allow most of the treatment sand to remain unsaturated during periods of high precipitation.

Mounds operated on the same principal as Oregon intermittent sand filters

(Chapter 3). However, mounds discharged treated wastewater to the natural topsoil below fill sands for final effluent purification and disposal while sand filters discharged treated effluent to disposal trenches placed into subsoils or permeable geological materials.

Intermittent doses of septic tank effluent were pumped from a dosing tank to a network of perforated plastic distribution pipes bedded in 12 in. of washed 3/4 in. to 2-1/2 in. gravel. Construction details for pressure distribution systems appear in Table 12-2 and Table 12-3. Information on hydraulic loading appears in Table 12-3. After dosed effluent passed through fill sand, it entered the natural topsoil, downgradient from the mound's pressure distribution system, for final treatment and disposal.

Pressure distribution systems were used in mounds to spread effluent evenly throughout the entire absorption bed or trench system, prevent saturated flow through filter media, and retard the development of biological clogging at the gravel-sand interface (8). Distribution systems were designed to operate with approximately 5 ft of head at the remotest orifice of each distribution lateral to keep orifices from clogging with organic matter. Pressure distribution system dose volumes were set so the majority of septic tank effluent applied at each pump cycle would be absorbed through the gravel-sand interface at the base of bed or trench gravel.

Fill sands were placed over native topsoil at the base of mounds after vegetation and debris had been removed and the soil had been plowed, perpendicular to the slope, to a depth of at least 6 in.

TABLE 12-2. MOUND PRESSURIZED DISTRIBUTION SYSTEM CONSTRUCTION DETAILS

SYSTEM	TYPE SYSTEM	SYSTEM DIMENSIONS	BOTTOM AREA (FT^2)	LATERAL DIA. (in)	ORIFICE DIA. (in)	ORIFICE SPACING (in. c-c)
1 (Nowodworski)	Trenches	4-2'x50'x1'	400	1.25	0.25	24
2 (Obrist)	Trenches	4-2'x50'x1'	400	1.5	0.25	30
3 (Royland)	Trenches	3-2'x42'x1'	252	1.5	0.25	24
4 (Suiter)	Beds	20'x20'x1'	400	1.0	0.25	30

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TABLE 12-3. ACTUAL MOUND HYDRAULIC LOADING

SYSTEM	SAND INFILTRATIVE SURFACE AREA (ft^2)	DESIGN FLOW (gpd)	ACTUAL FLOW (gpd)	LOADING RATE ($g/ft^2/d$)	DOSE VOLUME (g/dose)	DOSING RATE ($g/ft^2/dose$)	DOSING FREQUENCY (doses/day)
1 (Nowodworski)	400	450	47	0.1	110	0.28	0.43
2 (Obrist)[1]	400	450	130-225	0.28 - 0.50	225	0.56	0.58 - 1.0
3 (Royland)	252	300	103	0.34	210	0.83	0.49
4 (Suiter)	400	450	319	0.71	215	0.54	1.48

---

[1] Daily flow estimated.

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Mound basal areas were sized so all treated effluent and incident precipitation would be absorbed by the topsoil before it reached the fill edge. Details identifying mound basal area characteristics are shown in Table 12-4.

Mounds were crowned with locally available topsoil to provide a barrier against freezing and exposure to the public and animals, increase runoff, and provide a medium for growing a protective vegetative cover.

Three mounds (Figure 12-1) were constructed on moderately permeable, somewhat poorly drained soils. The annual precipitation at these sites ranged from 37.61 to greater than 50 in. (5, 9). These mounds used trenches placed above 30 in. of sand fill to keep wastewater dispersed over a broad area and keep pressure distribution systems elevated far enough over groundwater to provide an adequate zone for septic tank effluent treatment during storm cycles.

One mound (Figure 12-2) was constructed on a well drained ridgetop over moderately permeable soils shallow to metamorphosed sandstone. The annual precipitation at the site averaged less than 31 in. (5). Soils at this location were well drained so there was little concern groundwater would rise into fill material during storm cycles. Consequently, a bed was placed above 24 in. of fill sand.

TABLE 12-4. MOUND SOIL ABSORPTION SYSTEM DETAILS

SYSTEM	MOUND BASAL AREA (ft^2)	TOPSOIL INFILTRATION RATE (in/hr)	 PERMEABILITY (in/hr)	 TEXTURE
1 (Nowodworski)	6,150	0.3	0.6 - 2.0	silt loam
2 (Obrist)	6,000	0.3	0.6 - 2.0	silt loam
3 (Royland)	3,360	0.3	0.6 - 2.0	silty clay loam
4 (Suiter)	4,850	0.3	0.6 - 2.0	silt loam

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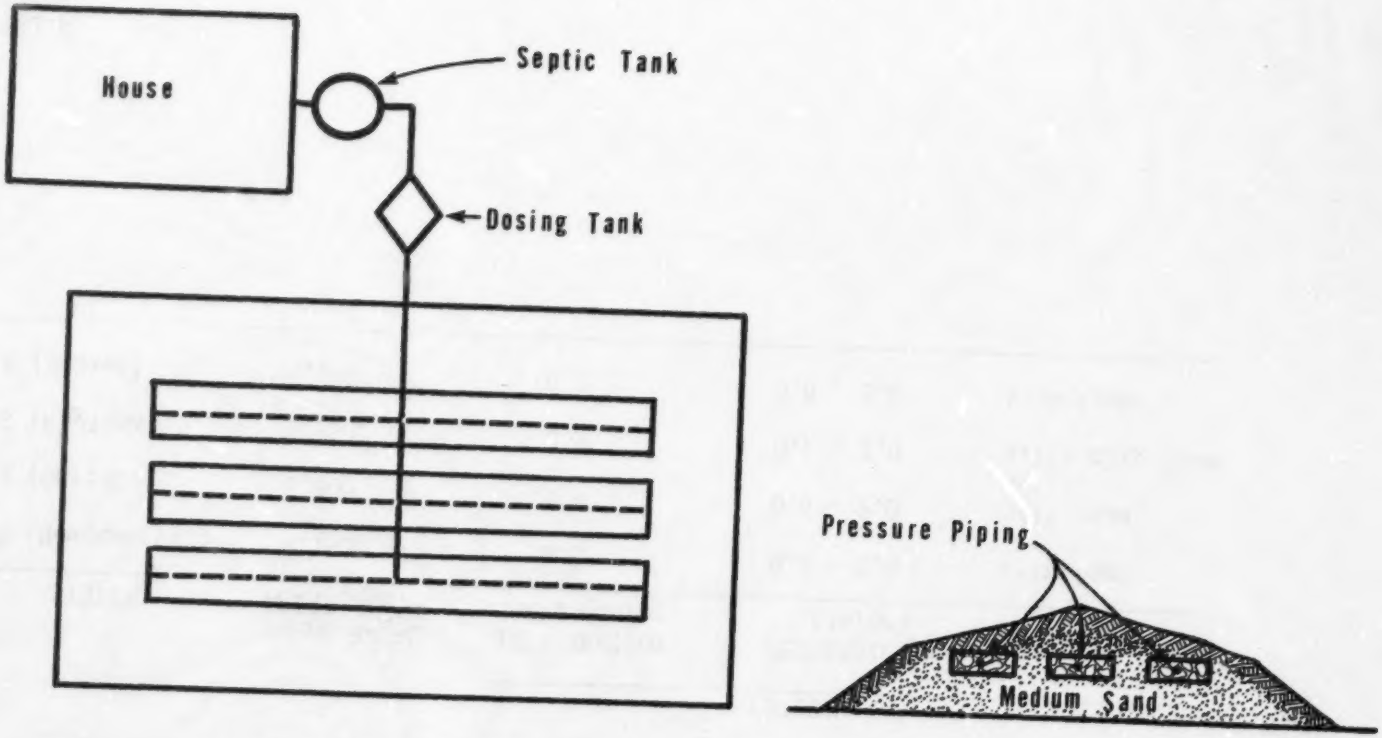
House
Septic Tank
Dosing Tank
Pressure Piping
Medium Sand

FIGURE 12-1. SAND FILL MOUND WITH PRESSURE DISTRIBUTION TRENCHES

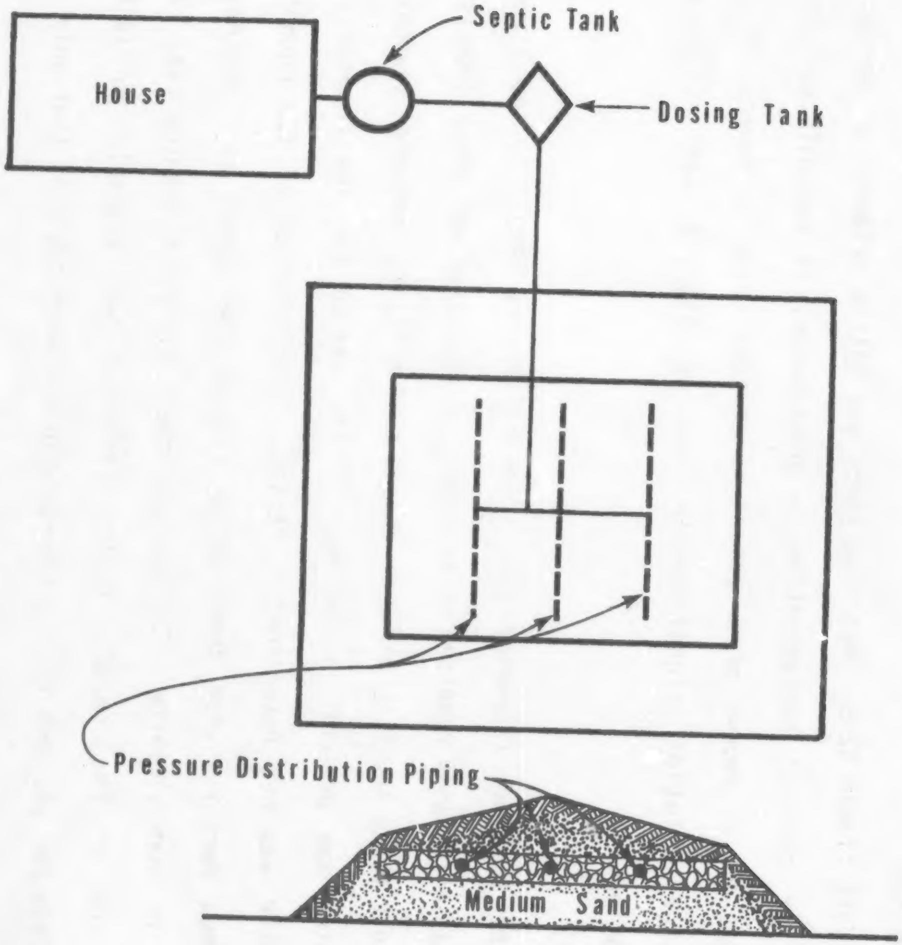
Septic Tank
House
Dosing Tank
Pressure Distribution Piping
Medium Sand

FIGURE 12-2. MOUND WITH PRESSURIZED DISTRIBUTION BED

MONITORING

Water samples were collected from monitoring ports 20 ft upgradient, below the center of the mound, and 20 ft downgradient and analyzed for total coliform, fecal coliform (10) and nitrate-nitrogen (11).

RESULTS AND DISCUSSION

MOUND TREATMENT

Although data (Table 12-5) indicated there was little evidence of serious bacterial or chemical contamination in groundwater, it was difficult to assess the actual degree of treatment which took place in mounds since groundwater dilution significantly lowered nitrate and coliform concentrations.

During the 10 times (November 1978 through February 1980), System 1 was monitored, fill sands remained unsaturated. Groundwater was never detected immediately above the fragipan even though soil mottling indicated seasonal groundwater was present in the past. The reason for the absence of groundwater was not determined. Perhaps, scarification of the mound's basal area during system construction altered the normal soil drainage pattern in that vicinity. The mound's small hydraulic loading rate (47 gal/d, 10% of the mound's design capacity) was probably partially responsible for the lack of a discernible groundwater table at that point.

Water samples collected near System 2 indicated the system had little measurable impact on groundwater. In spite of the fact groundwater levels remained an average of 11 in. below pressure distribution trenches during

TABLE 12-5. MOUND WATER QUALITY MONITORING DATA

SYSTEM	MONITORING WELL LOCATIONS [1]								
	20' UPGRADIENT OF PRESSURE DIST. SYSTEM			BELOW CENTER OF PRESSURE DIST. SYSTEM			20' DOWNGRADIENT OF PRESSURE DIST. SYSTEM		
	NO_3 [2]	FC [3]	TC	NO_3	FC	TC	NO_3	FC	TC
1 (Nowodworski)	none	none	none	dry	dry	dry	none	none	none
2 (Obrist)	0.25 (2)[4]	13 (19)	580 (5)	1.29 (2)	105 (21)	2,565 (6)	0.47 (1)	29 (18)	1,098 (5)
3 (Royland)	none	none	none	none	none	none	1.83 (4)	210 (5)	3,195 (3)
4 (Suiter)	none	none	none	none	none	none	---	5,000 (1)	9,000 (1)

---

[1] None = no monitoring well installed.
Dry = monitoring well always dry at time of observations.

[2] Nitrate nitrogen expressed as mg/l; arithmetic mean.

[3] Fecal and total coliform expressed as mg/l; geometric mean.

[4] Number of samples

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high rainfall months (data not shown), a high degree of bacteriological and chemical treatment took place as septic tank effluent moved through fill sand.

Data indicated treated effluent underwent further dilution by groundwater as it moved away from the mound's pressure distribution system. Fecal coliform (105 org/100 ml) detected in groundwater in samples collected below the center of the mound's pressure distribution system were nearly 4 times higher than fecal concentrations (29 org/100 ml) found 20 ft downgradient from pressure distribution trenches. Total coliform and nitrate nitrogen numbers showed similar declines with distance as effluent moved from the pressure distribution system.

Bacterial and nitrate nitrogen concentrations detected in groundwater 20 ft downgradient from System 3 indicated that system had little adverse impact on the environment.

Groundwater was observed on one occasion at System 4. Bacterial analysis indicate some saturated flow may have occurred between the pressure distribution bed and groundwater. Several rodent burrows in the immediate vicinity of the downgradient monitoring well suggested bacterial numbers were probably due to short circuiting of partialy treated effluent into the monitoring well.

MOUND OPERATION AND MAINTENANCE

Table 12-6 shows site conditions at mound locations and general performance of mound soil absorption systems observed during the 20-55 month period systems were studied. Although effluent surfacing was not apparent downgradient from any mound, during periods of heavy rainfall, surface water often appeared within a few feet of System 2 and System 3 toeslopes. However, saturated soil extended evenly across a broad area downgradient from these mounds so wetness appeared to be due to a combination of heavy rainfall and change in relief rather than the influence of mound effluent.

The pressure distribution bed at System 4 (the mound receiving the greatest average daily flow 319 gpd), was unearthed to determine the condition of fill sand (effective size 0.25; uniformity coefficient 3.4) at the bed's gravel-sand interface after 45 months of operation. No biological mat had developed at the base of the bed. This observation suggested mound pressure distribution systems may operate indefinitely without clogging provided they are not hydraulically overloaded or subjected to effluents with unusually high waste strengths.

During the 55 month period System 2 was observed, 2 submersible effluent pumps failed. The first failure occurred after 37 months of operation. The second submersible pump failed after 18 month's use when a mercury float on-off switch connected to the pumps by a fixed rod detached. Free floating switches required in the system's original permit were replaced with the fixed arm float when the system's second pump was installed. Pump failures were not observed at other mound installations.

TABLE 12-6. A DESCRIPTION OF SITE CONDITIONS AND MOUND PERFORMANCE

FEATURE DESCRIBED	SYSTEM			
	1 (NOWODWORSKI)	2 (OBRIST)	3 (ROYLAND)	4 (SUITER)
Soil Absorption System Site Limitation	Seasonal groundwater; mottling at 15-22 in.; dense fragipan at 17-25 in.	Seasonal groundwater; mottling at 8-12 in.; dense fragipan at 12-14 in.	Seasonal groundwater; mottling at 4-6 in.; dense clay pan at 10-17 in.	12-18 in. to fractured weathered basalt
Soil Texture Below Mound Base	silt loam	silt loam	silty clay loam	silt loam
Slope (%)	7	4	12	2-12
Average Mound Loading Rate (gpd)	47	130-225[1]	103	319
Annual Precipitation	39.91	39.91	50.35	30.96
Effluent Absorption By Topsoil	Satisfactory	Satisfactory	Satisfactory	Satisfactory
Mound Installation Date	October 1977	December 1976	August 1976	July 1976
Observation Period	Nov. 1978-July 1980	Dec. 1976-July 1981	August 1976-Nov. 1980	March 1978-Dec. 1981
Number of Observations	14	21	12	8

[1] Flow estimated.

XG943.C

CONCLUSION

Mounds functioned satisfactorily on nearly level to sloping Western Oregon sites where medium textured or coarser soils were shallow to groundwater or fractured rock and the annual precipitation was less than 50 in. However, landform, sand cost, and availability of natural topsoil substantially limited the practical application of mounds at many Oregon locations where sand filter systems were suitable for site development.

Consequently, no mounds were permitted in the experimental program after 1977. Further mound testing was abandoned for the following reasons:

1. Few Oregon sites, which were not acceptable for standard septic tank soil absorption system development, had topographic features (i.e., simple slopes of less than 12%) or topsoil characteristics (medium or coarser textured soils) with high enough infiltration rates to absorb septic tank effluent plus all precipitation which fell annually between November and April;

2. Many soils, based on the recommendation of Bouma and Wisconsin mound designers, were too shallow, (less than 24 in.) to seasonal groundwater, fractured or weathered rock, or hardpans to be suitable to absorb both septic tank effluent and seasonal precipitation;

3. The actual level of treatment provided by mound filtration was difficult to evaluate because of the influence of groundwater dilution;

4. Large quantities of sand (up to 600 yds^2) were required in mound construction and nearby sand sources with desirable media characteristics were not always readily available, adding substantially to construction costs; and

5. Extensive field testing of mounds was already underway in Wisconsin.

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CHAPTER 13

GRAY WATER

Nearly 35% of the total wastewater generated in a house is derived from the toilet (1). Composting toilets (Chapter 14) were used in Oregon to eliminate water transport of toilet wastes to conserve water and reduce the potential for groundwater pollution.

Gray water was pretreated by a number of devices to determine their capacity to remove suspended and settleable solids and to protect soil absorption trenches against premature clogging caused by these substances (2,3). Since gray water contains a variety of objectionable chemical and bacteriological characteristics, gray water effluents were discharged to disposal trenches for final treatment and disposal (4,5,6). Due to the reduced hydraulic load which resulted from compost toilet use; gray water disposal fields were 50% smaller than they would have been had water flush toilets been used.

A 198-gal septic tank, 55-gal pea-gravel filter, 132-gal trickle rock ("roughing") filter, and a small recirculating sand filter preceded by a 750-gal septic tank were installed and monitored to determine which would produce the highest quality effluent. BOD_5, SS, nitrogen and coliform densities in effluents from these treatment devices were compared with effluent produced by the treatment of gray water in a standard 1,000-gal septic tank.

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RESULTS AND DISCUSSION

RECIRCULATING SAND FILTER

A 64-ft^2 recirculating sand filter (Figure 13-1) preceded by a 750-gal septic tank was used to treat gray water from a shower, lavatory, and kitchen sink. Effluent drained from the septic tank into a recirculation tank, which contained a small submersible effluent pump, and mixed with previously filtered effluent. Mixed wastewater was applied to the open sand filter surface 5 times daily through 5 spray heads. Spray cycles lasted 2 minutes. Recirculation events were regulated by a percentage timer. Treated effluent discharged into two 125-ft long disposal trenches.

The recirculating sand filter (Table 13-1) produced a higher quality effluent than other graywater pretreatment systems. BOD_5, SS, and fecal coliform averaged 2.22 mg/l, 10.5 mg/l, and 15 org/100 ml respectively. Total nitrogen was 5.02 mg/l. Most nitrogen was in the nitrate form. The sand filter reduced total phosphate from 2.14 mg/l to 0.19 mg/l. Phosphate removal was attributed to phosphate fixation in filter sand (7,8).

Dosing the recirculating sand filter for 10 minutes each day resulted in aerobic treatment and better quality effluent than was produced in similar studies in Wisconsin (9,10,11). The residents had no children, worked away from home during the day, followed a diet that included a small amount of meat, and used an organic low phosphate soap. In addition, average daily hydraulic loading rates (27 gpd) were very low and much of the effluent evaporated as it was recirculated through the sprinkler head to the sand filter surface during warm, dry, summer months.

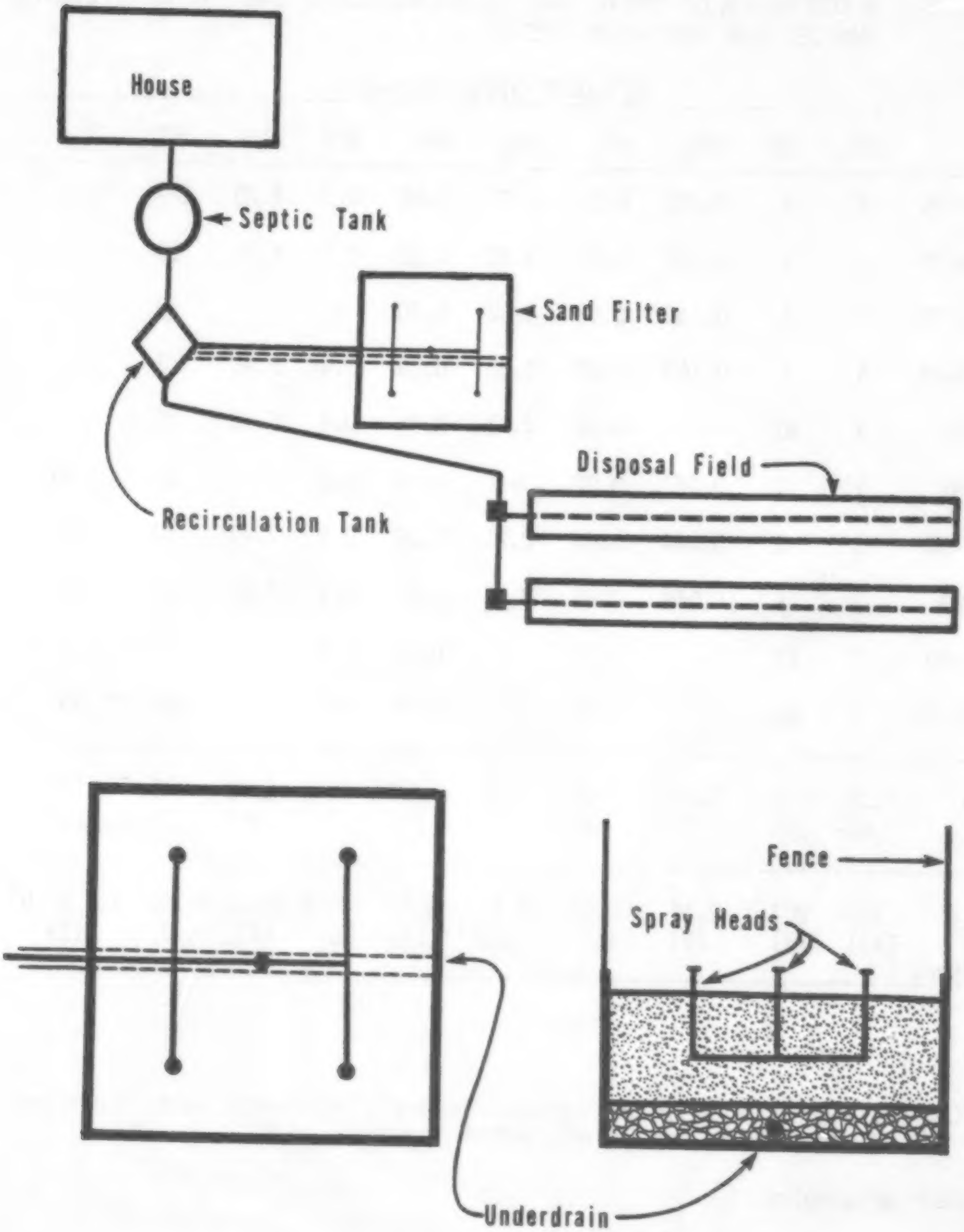
House
Septic Tank
Sand Filter
Disposal Field
Recirculation Tank
Fence
Spray Heads
Underdrain

FIGURE 13-1. GRAY WATER RECIRCULATING SAND FILTER SYSTEM

TABLE 13-1. A COMPARISON OF SEPTIC TANK AND RECIRCULATING SAND FILTER EFFLUENTS; VAN DER WERF GRAY WATER SYSTEM[1]

DATE	EFFLUENT CHARACTERISTIC[2]									
	BOD_5	SS	TPO_4	NO_2	NO_3	NH_3	TKN	TN	FC	TC
10-17-79	2	6	0.239	0.02	4.41	0.06	0.3	4.73	100	-
10-25-79	-	1	0.247	0.02	3.76	0.18	0.5	4.28	10	-
11-15-79	1	5	0.180	0.02	5.02	0.20	-	-	10	-
12-13-79	1	7	0.169	0.02	5.56	0.09	0.4	5.98	2	-
1-3-80	1	30	-	0.02	4.71	0.08	0.4	5.13	10	-
5-8-80	1	8	0.077	0.02	-	0.04	0.2	-	10	100
5-22-80	3	5	0.244	0.02	2.21	0.06	0.2	2.43	10	100
6-4-80	3	1	0.169	0.02	7.25	0.07	0.3	7.57	20	200
8-21-80	7	17	-	-	-	0.06	0.9	-	10	-
10-30-80	1	25	-	0.02	-	0.08	0.5	-	120	20,000
Mean	2.22 (9)[3]	10.5 (10)	0.19 (7)	0.02 (9)	4.70 (7)	0.09 (10)	0.41 (9)	5.02 (6)	15 (10)	737 (3)
Septic Tank Effluent	103 (13)	207 (13)	2.14 (9)	0.02 (13)	0.15 (13)	5.74 (13)	18.18 (13)	18.35 (13)	8,150 (10)	1.6×10^6 (3)

---

[1] Flow averaged 27 gpd.

[2] BOD_5, SS, and PO_4 and nitrogen expressed as mg/l; arithmetic mean. Coliform densities expressed as org/100 ml; geometric mean.

[3] Number of samples.

PEA-GRAVEL FILTER

The 55-gal pea-gravel filter (Figure 13-2) was preceded by a nylon filter stocking to remove gross solids. After gray water drained through the filter stocking, it trickled onto a splash plate at the filter surface and passed through a layer of medium sand and a gravel covered underdrain into a sample collection box. Overflow discharged to a sanitary sewer.

Gray water was generated from a lavatory, wash basin, bathroom tub/shower, and kitchen sink. Dishes were washed manually using biodegradable detergent. System users consumed very little meat and were careful to keep greases, fats, and oils out of the treatment and disposal system.

The pea-gravel filter was not preceded by a septic tank. As a result, effluent quality data (Table 13-2) were quite variable. BOD_5 ranged from 5 mg/l to 243 mg/l and SS ranged from 20 mg/l to 1086 mg/l. Similar variations were observed in NH_3, NO_3, TN, TKN, and fecal coliform densities. The broad range in effluent quality was attributed to the varied nature of the waste generating events and lack of effluent stabilization due to the absence of a septic tank or surge tank.

TRICKLE ROCK FILTER

A gravel filled, gravity-fed, 132-gal "roughing filter", similar in design to the trickle filter, had little effect on gray water treatment. BOD_5 and SS (Data not shown) were considerably higher than levels that occurred in the 1,000-gal septic tank effluent (Table 13-4). Observations indicate the roughing filter did not provide adequate treatment.

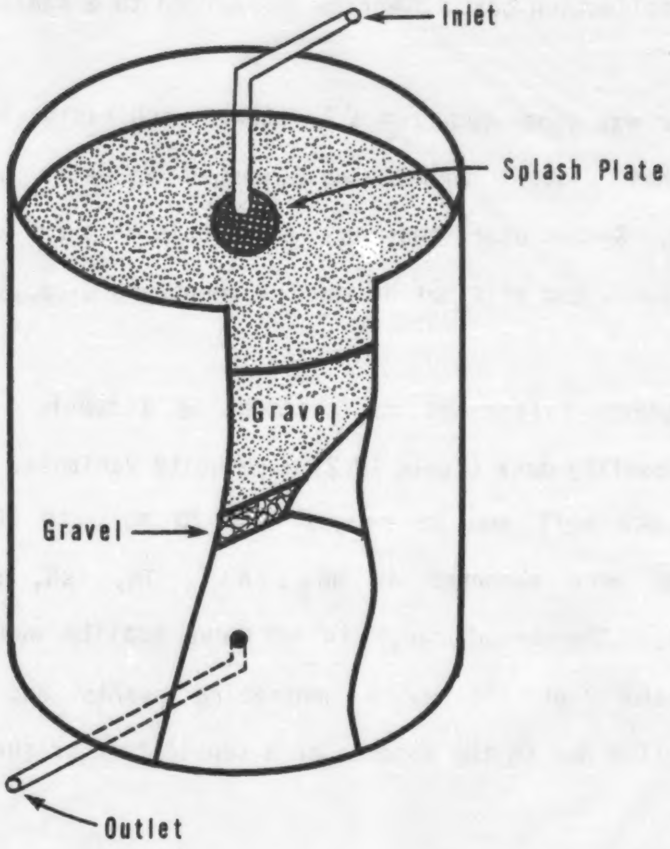
Inlet
Splash Plate
Gravel
Gravel
Outlet

FIGURE 13-2. PEA-GRAVEL FILTER

TABLE 13-2. BENDER 55-GALLON PEA-GRAVEL FILTER EFFLUENT QUALITY [1]

	EFFLUENT CHARACTERISTIC[2]								
DATE	BOD_5	SS	NO_2	NO_3	NH_3	TKN	TN	FC	TC
7-19-79	51	1086	0.03	0.74	0.4	34.0	34.8	3.0×10^5	-
11-7-79	5	20	0.03	3.53	0.25	3.7	7.3	400	-
1-2-80	28	99	0.08	1.09	3.2	24.0	25.2	1.0×10^6	-
1-16-80	44	292	0.26	11.64	1.1	51.0	62.9	1.0×10^6	-
3-20-80	44	173	0.04	9.94	0.5	17.0	27.0	1.3×10^4	-
4-8-80	10	33	-	1.74	0.31	1.3	3.0	100	3.2×10^5
5-14-80	141	705	0.02	4.90	1.0	34.0	38.9	2000	4.0×10^5
5-22-80	63	190	-	1.59	0.7	21.0	22.6	4500	2.8×10^6
10-29-80	19	46	0.02	52.80	0.31	30.0	82.8	10	100
12-3-80	243	65	0.02	0.60	0.41	27.3	27.9	1.4×10^4	3.3×10^5
Mean	65 (10)[3]	271 (10)	0.06 (8)	8.85 (10)	0.82 (10)	24.3 (10)	33.2 (10)	6.75×10^3 (10)	1.1×10^5 (5)

[1] Flow averaged 49 gpd. System used by 2 adults and 1 child.

[2] BOD_5, SS, and nitrogen expressed as mg/l; arithmetic mean. Coliforms expressed as org/100 ml; geometric mean.

[3] Number of samples.

CIPAX 198-GALLON SEPTIC TANK

This system consisted of a 198-gal septic tank (Figure 13-3) followed by 3 disposal trenches 50 ft long. Wastewater was generated from a kitchen sink, 2 lavatories, a bathtub, a shower, and an automatic clothes washer.

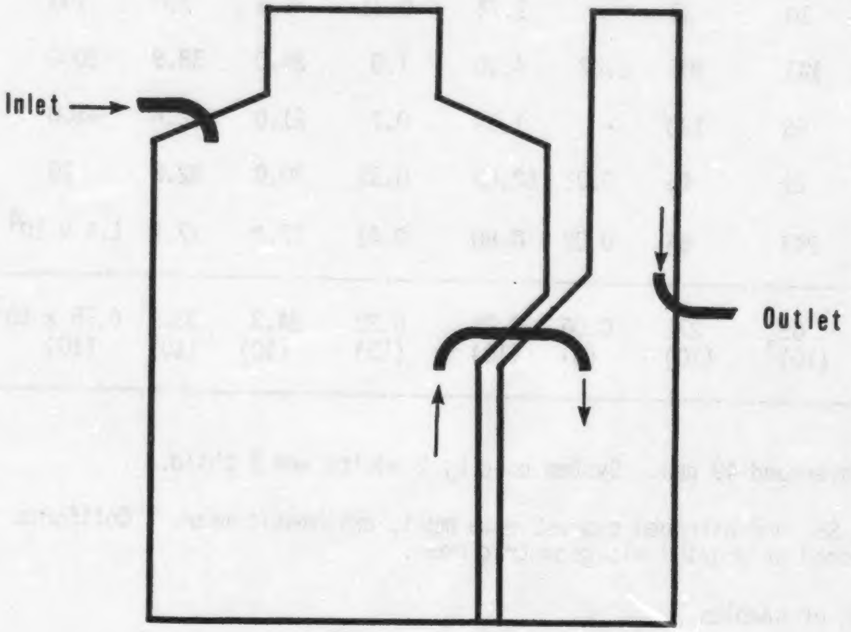
Inlet
Outlet

FIGURE 13-3. CIPAX 198-GALLON SEPTIC TANK

Septic tank effluent quality (Table 13-3) indicated that the 198-gal septic tank provided reasonable surge stability. Wastewater residence time was about 45 hours based on an average daily flow of 106 gal (Table 13-3; Footnote 1). BOD_5 and SS were high (268 mg/l and 167 mg/l) but not as variable as they were in the trickle sand filter (Table 13-3) and gravity fed gravel filter which lacked surge protection.

TABLE 13-3. FRANS GRAY WATER 198-GALLON SEPTIC TANK EFFLUENT QUALITY [1]

	EFFLUENT CHARACTERISTIC[2]								
DATE	BOD_5	SS	NO_2	NO_3	NH_3	TKN	TN	FC	TC
11-7-79	230	192	-	0.81	0.75	7.0	7.87	4.8×10^5	1.0×10^5
1-9-80	306	100	0.03	0.67	2.55	12.0	12.7	1.0×10^5	1.0×10^6
2-6-80	219	416	0.02	0.59	1.64	10.4	11.01	1.0×10^6	1.0×10^7
4-30-80	198	120	0.02	0.02	2.26	11.5	11.54	1.0×10^5	8.0×10^6
5-28-80	263	64	0.02	2.14	4.9	16.8	18.96	1.3×10^4	-
6-12-80	327	102	0.02	0.18	2.27	11.6	11.8	-	-
8-20-80	348	228	0.02	0.23	0.84	12.8	13.5	1.0×10^6	1.0×10^7
11-28-80	185	50	0.02	0.10	2.29	9.2	9.32	-	-
1-14-81	348	228	0.02	0.21	0.45	0.7	2.93	1.0×10^6	1.0×10^7
2-12-81	260	-	-	0.10	2.33	9.25	9.35	-	-
Mean	268 (10)[3]	167 (10)	0.02 (8)	0.5 (10)	2.0 (10)	10.3 (10)	10.9 (10)	3.1×10^5 (7)	3.0×10^6 (6)

[1] Flow averaged 106 gpd. System used by 2 adults and a child.

[2] BOD_5, SS, and nitrogen expressed as mg/l; arithmetic mean. Coliforms expressed as org/100 ml; geometric mean.

[3] Number of samples.

STANDARD 1000-GALLON SEPTIC TANK

This system was used by one adult who produced an average of 17.5 gal of wastewater per day. Wastewater from a kitchen sink, automatic dishwasher (seldom used), automatic clothes washer, two lavatories, and a bathtub/shower combination drained into a 1000-gal septic tank.

TABLE 13-4. MEADOR 1000-GALLON SEPTIC TANK EFFLUENT CHARACTERISTICS[1]

	EFFLUENT CHARACTERISTIC[2]								
DATE	BOD_5	SS	NO_2	NO_3	NH_3	TKN	TN	FC	TC
1-9-80	135	1	0.02	0.2	1.12	4.1	4.32	1.0×10^5	1×10^6
2-6-80	160	64	0.02	0.14	0.21	3.0	4.06	1.0×10^6	3.1×10^6
4-23-80	438	33	0.02	0.57	0.23	5.6	6.19	3.5×10^4	9×10^5
5-28-80	254	14	0.02	1.64	0.18	5.6	6.26	2.2×10^5	2.8×10^5
6-11-80	324	33	0.02	0.04	1.0	4.6	4.66	3.0×10^4	2×10^5
7-25-80	336	104	0.02	0.01	5.41	11.6	11.63	-	3.9×10^5
8-20-80	171	20	0.02	0.02	0.94	9.8	9.82	2.1×10^5	2.2×10^5
11-28-80	390	52	0.02	0.08	7.05	10.5	10.6	-	-
1-14-81	170	20	0.02	0.02	2.63	6.8	6.82	1.0×10^5	1.0×10^7
2-11-81	135	23	-	0.10	2.08	6.0	6.1	7.5×10^5	6.5×10^6
3-11-81	62	13	0.02	0.02	2.22	8.0	8.2	3.0×10^2	1.1×10^6
Mean	234 (11)[3]	34 (11)	0.02 (10)	0.26 (11)	2.1 (11)	7 (11)	7.26 (11)	1.0×10^5 (9)	6.3×10^5 (10)

---

[1] Flow averaged 17.5 gpd. System used by 1 adult.

[2] BOD_5, SS, and nitrogen expressed as mg/l; arithmetic mean. Coliforms expressed as org/100 ml; geometric mean.

[3] Number of samples.

Effluent from the septic tank was discharged into five 45-ft long disposal trenches.

Results of the study (Table 13-4) are similar to those reported in Wisconsin (11) and Canada (12) except BOD_5 values were somewhat higher and TKN values were about half. When compared to septic tank effluent generated from total residential wastewater flow (4), gray water contained lower concentrations of nitrogen and somewhat higher concentrations of BOD_5. In addition, total and fecal coliform densities were one log lower.

CONCLUSIONS

Gray water treatment systems did not eliminate the necessity for subsurface disposal fields. Data showed that gray water had comparable or higher levels of fecal coliform, BOD_5, and SS than combined waste streams. Although these components were attenuated through pretreatment devices, the only justification for different permit standards for split waste systems should be based on reduced hydraulic loading.

The most economical and practical method for gray water disposal was a standard septic tank with a reduced size disposal field.

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CHAPTER 14

COMPOSTING TOILETS

One of the main sources of pollution associated with modern houses is the large amount of water used to transport toilet waste to the septic tank. If water transport can be eliminated, it would not only reduce the potential problem of pollution, but would also result in water conservation. In addition, use of smaller disposal fields may be practical as well as use of marginal soils for disposal of gray water. These considerations have generated considerable interest in the idea of separating toilet waste from the remainder of the household waste stream.

Forty-one permits were issued for installation of composting toilets. Twenty-eight toilets were installed. Many toilet users had difficulty learning how to use and maintain their units properly. Some users were pleased with their composting toilet but many were not. Many complained of solid and liquid waste buildup, odors, and flies. Six users removed their units and replaced them with conventional toilets because of these problems. Compost toilet performance and user acceptance is discussed in detail in progress reports February 28, 1978 (Appendix E), January 30, 1979 (Appendix F) and December 30, 1979 (Appendix G).

Composting toilets were dropped from the experimental program October, 1977 when the Oregon Department of Commerce assumed legal jurisdiction.

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CHAPTER 15

CHARACTERISTICS OF RESIDENTIAL AND INDUSTRIAL SEPTIC TANK EFFLUENTS

The septic tank is a very simple device for treatment of household waste prior to discharge into a soil absorption system. Its main function is to remove settleable solids and floating scum and change the character of non-settleable solids by anaerobic digestion. The effluent discharged is relatively free of settleable solids but contains non-settleable solids and soluble organic matter.

The septic tank and disposal field are used extensively in Oregon for treatment and disposal of household waste, but little has been done to characterize septic tank effluent. This study was undertaken to determine the quality of household and industrial effluents in order to design and evaluate on-site treatment and disposal alternatives.

METHODS

Effluent was characterized from 8 residential systems and 2 industrial systems. Double compartment tanks were used in residential Systems 1, 2, and 7 (Table 15-1). Single compartment tanks were used for the rest of the residential systems and the 2 industrial systems (Table 15-2). Industrial System 1 used a 2,000 gal tank for the sawmill and a 1,500 gal tank for the office building. Sewer lines from these 2 facilities flowed into a pump tank where effluent samples were collected.

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TABLE 15-1. DETAILS OF RESIDENTIAL SEPTIC TANKS.

System	Tank Vol. (gal)	Compartments[1]	Const. Material	Fittings
1 (McCurley)	1250	2	Concrete	Cast Iron
2 (Gilkey)	1250	2	Concrete	Cast Iron
3 (Grooms)	1000	1	Concrete	Cast Iron
4 (Boettcher)	1000	1	Concrete	Cast Iron
5 (Reber)	1000	1	Concrete	Cast Iron
6 (McClaflin)	1000	1	Concrete	Cast Iron
7 (Roberts)	1250	2	Concrete	Cast Iron
8 (Anderson)	1000	1	Concrete	Cast Iron

[1] Two compartment tanks had a liquid capacity of 825 gal in the first chamber and 425 gal in the second chamber.

TABLE 15-2. DETAILS OF INDUSTRIAL SEPTIC TANKS.

System	Facility	Tank Vol. (gal)	Compartments	Const. Material	Fittings
1. (International Paper Co.)	Sawmill Office Bldg.	2000, 1500[1]	1	Concrete	Cast Iron
2. (Weyerhaeuser Ore-Aqua Inc.)	Watchman's Trailer, Operations Bldg.	1000	1	Fiberglass	SCH 40 ABS

[1] The 2000 gal septic tank served the sawmill and the 1500 gal septic tank served the office building.

Average daily flow was recorded for each system except residential System 8 and effluent samples were collected and analyzed for BOD_5, SS, NO_3, NH_3, total kjeldahl nitrogen (TKN), total nitrogen (TN), fecal coliform (FC), and total coliform (TC). (1, 2).

RESULTS AND DISCUSSION

RESIDENTIAL SEPTIC TANK EFFLUENT QUALITY

Average flow from residential systems was 164 gpd (Table 15-3).

TABLE 15-3. CHARACTERISTICS OF 8 SINGLE FAMILY RESIDENTIAL SEPTIC TANK EFFLUENTS

	SEPTIC TANK EFFLUENT CHARACTERISTICS [1]									
System	Ave. Flow (gpd)	BOD$_5$	SS	NO$_2$	NO$_3$	NH$_3$	TKN	TN	FC	TC
1 (McCurley)	191	149 (8)[2]	240 (8)	0.02 (9)	0.18 (9)	37.8 (9)	56.9 (9)	57.1 (9)	2.0×10^4 (10)	1.5×10^5 (8)
2 (Gilkey)	113	197 (11)	38 (11)	0.02 (10)	0.81 (10)	35 (10)	58.4 (10)	59.20 (10)	1.1×10^5 (10)	1.8×10^6 (9)
3 (Grooms)	139	188 (7)	79 (7)	0.02 (6)	0.04 (7)	35.5 (7)	45.6 (7)	45.67 (6)	7.0×10^4 (6)	7.7×10^5 (5)
4 (Boettcher)	194	222 (11)	193 (11)	-	-	-	-	-	-	-
5 (Reber)	176	378 (7)	276 (7)	0.03 (7)	0.16 (6)	53.3 (7)	71.8 (6)	71.9 (5)	5.4×10^5 (6)	2.1×10^7 (6)
6 (McClaflin)	161	125 (16)	91.7 (16)	0.02 (15)	0.56 (16)	36.1 (16)	51.3 (16)	51.80 (15)	8.0×10^4 (14)	9.9×10^5 (10)
7 (Roberts)	174	348 (7)	171 (7)	0.02 (7)	0.38 (8)	55.9 (8)	70.5 (7)	70.9 (7)	1.0×10^6 (8)	2.5×10^6 (6)
8 (Anderson)	---	322 (3)	203 (3)	0.02 (3)	0.24 (3)	32.56 (3)	47.2 (2)	47.45 (2)	8.1×10^4 (2)	1.3×10^6 (2)
Weighted Arithmetic Average	164 (7)	217 (70)	146 (70)	0.02 (57)	0.4 (59)	40.6 (60)	57.1 (57)	57.5 (54)	2.6×10^5 (56)	1.32×10^6 (46)

---

[1] BOD$_5$, SS, and Nitrogen expressed as mg/l (arithmetic mean) and coliform densities expressed as org/100 ml (geometric mean).

[2] Number of samples.

This was about 36% of the design flow. The mean BOD_5 concentration was 217 mg/l. Corresponding BOD_5 values of 138 mg/l (1), 132 mg/l (2), and 152 mg/l (3) reported in Wisconsin and 120 mg/l (4) reported in Connecticut were somewhat lower but a study in Canada (5) reported a value of 240 mg/l. Suspended solids concentration in Oregon septic tank effluents averaged 146 mg/l. This ranged from 1.7 to 4.2 times higher than corresponding SS concentrations reported in Wisconsin, Connecticut, and Canada (3, 4, 5, 6, 7).

BOD_5 and SS values for System 6 (Table 15-3) were abnormally low. The home owners followed the practice of flushing a septic tank treatment tablet down the toilet each day. The tablet manufacturer alleged the product would increase septic tank treatment effectiveness. Special biodegradable toilet paper was used exclusively. In addition, no household garbage disposal unit was used and grease, oils, and fats were removed from dishes and pans and discarded prior to washing. These factors may have lowered the BOD_5 and SS concentration in the septic tank effluent.

The total nitrogen concentration was 57.5 mg/l (Table 15-3). Studies in Wisconsin (3, 4, 5, 8) reported concentrations that ranged from slightly below to slightly above this value. More than 99% of the inorganic nitrogen was in the reduced form indicating the anaerobic nature of the septic tank.

Total coliform and fecal coliform concentrations were similar to those commonly reported (9, 10, 11).

INDUSTRIAL SEPTIC TANK EFFLUENT QUALITY

Characteritics of 2 industrial septic tank effluents are shown in Table 15-4.

TABLE 15-4. CHARACTERISTICS OF 2 INDUSTRIAL SEPTIC TANK EFFLUENTS.

	SEPTIC TANK EFFLUENT CHARACTERISTICS[1]									
System	Ave. Flow (gpd)	BOD_5	SS	NO_2	NO_3	NH_3	TKN	TN	FC	TC
1. (International Paper Corp.)	3000	53.6 (11)[2]	39.6 (8)	0.04 (11)	1.18 (10)	49 (8)	76.25 (8)	77.47 (8)	3.4×10^5 (10)	4.3×10^5 (6)
2. (Weyerhaeuser Ore-Aqua Inc.)	30	161 (9)	33 (9)	0.05 (9)	0.65 (9)	50 (9)	72.8 (9)	73.5 (9)	9.5×10^4 (9)	5.1×10^5 (9)
Weighted Arithmetic Average	1550 (2)	102 (20)	36.1 (17)	0.04 (2))	0.94 (20)	49.5 (19)	74.4 (17)	75.4 (17)	2.3×10^5 (18)	4.4×10^5 (7)

[1] BOD_5, SS, and Nitrogen expressed as mg/l (arithmetic mean) and fecal and total coliform expressed as org/100 ml (geometric mean).

[2] Number of samples.

Total coliform and fecal coliform concentrations were similar to household septic tank effluent because of the toilet facilities, but total nitrogen and ammonia nitrogen were considerably higher. Average BOD_5 and SS concentrations were 50% and 25% of those in household waste streams. Unfortunately, no data from comparable industrial facilities were available for comparison.

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CHAPTER 16

SUBSURFACE SYSTEM COST

Selecting the proper on-site subsurface treatment and disposal system involves the process of evaluating technical feasibility, environmental acceptability, and cost effectiveness of various alternatives. Professional staff have responsibility for realistically applying regulations (Appendix C) to insure adequate long-term sewage treatment and disposal with a minimum hazard to the environment. As a result, some individual property owners are denied freedom to use their property as they choose. More often, they are denied a permit to install a standard subsurface treatment and disposal system but are given the option of installing an alternative system designed to overcome specific limitations of their site. Table 16-1 assists in selection of options applicable to various site limitations. Once the options are identified the property owner can determine which system is the most feasible to construct.

Alternative systems are usually more complex and more expensive to construct and maintain than standard subsurface systems. Estimates of capital and operation and maintenance costs of each on-site system allows the owner to decide if it is economically feasible to develop his property and which alternative is the most cost effective.

Cost estimates were developed primarily from information obtained from construction and operation of on-site systems developed in the On-site

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TABLE 16-1. OREGON ON-SITE SUBSURFACE SYSTEMS VS. SITE CONSTRAINTS

		SITE CONSTRAINTS												
		SOIL PERMEABILITY			SOLID BEDROCK OR SOIL PANS		DEPTH TO SAPROLITE OR FRACTURED BEDROCK		GROUNDWATER		SLOPE			
	SYSTEM	VERY RAPID RAPID	MODERATELY SLOW MODERATE MODERATELY RAPID	VERY SLOW SLOW	SHALLOW	DEEP	SHALLOW	DEEP	SHALLOW	DEEP	0-12%	12-30%	30-45%	SMALL LOT
	Standard Subsurface System		X			X		X		X	X	X		
	Capping Fills	X	X		X	X	X	X	X	X	X			
a	Evapotranspiration Absorption			X		X		X		X	X	(15%)		
a	Pressurized Distribution	X	X			X		X		X	X	X		
a	Intermittent Sand Filter System	X	X	X	X	X	X	X	X	X	X			X
a	Steep Slope System		X			X		X		X			X	
a	Tile Dewatering System	X	X			X		X	X		(3%)			
a	Split Waste System		X			X		X		X	X	X		
b	Disposal Trenches in Soils with Slow and Very Slow Permeabilities			X	X	X	X	X		X	X	(20%)		
b	Seepage Trenches in Soils with Slow and Very Slow Permeabilities			X		X		X		X	X (10% min)	X		
b	Disposal Trenches in Soils Shallow to Duripans, saprolite or fractured bedrock		X	X	X		X			X	X	X		
b	Pressurized Distribution Trenches in Soils Shallow to Groundwater	X	X			X		X	X		(3%)			
b	Evaportranspiration Bed	X	X	X	X	X	X	X	X	X	X			
b	Mounds	X	X		X		X		X		X			

X Means system can function effectively with that constraint.

a Alternative systems established on the basis of Oregon's Experimental Program.

b Experimental systems which have not been adopted as alternative systems.

Experimental Systems Program. Plans and specifications were prepared by the Department of Environmental Quality (DEQ) staff. Systems were constructed either by the individual land owner or by a licensed installer contracted by the land owner. Cost ranges reflect variations in labor and material costs. All costs were based on 1981 dollars.

RESULTS AND DISCUSSION

The standard system had the lowest construction cost and operation and maintenance cost (Table 16-2). Construction costs were low because of the

Table 16-2. SUBSURFACE SYSTEM CONSTRUCTION AND OPERATION AND MAINTENANCE COSTS ($)

SYSTEM	CONSTRUCTION[1]	OPERATION AND MAINTENANCE
Standard	1,000 - 2,500	10.00 - 25.00[2]
Recirculating Sand Filter	4,000 - 5,300	31.50 - 65.00[3]
Intermittent Sand Filter		
Bottomless (No Disposal Field)	2,500 - 3,500	28.50 - 62.00[3]
Concrete Lined Sand Filter	6,500 - 10,000	28.50 - 62.00[3]
Intermittent Recirculating Sand Filter	5,100 - 9,600	31.50 - 65.00[3]
Tile Dewatering	3,500 - 5,500	10.00 - 25.00[2]
Seepage Trench	1,900 - 3,700	10.00 - 25.00[2]
Steep Slope	2,400 - 5,000	10.00 - 25.00[2]
Saprolite	1,250 - 3,000	10.00 - 25.00[2]
Pressure Distribution	2,200 - 3,500	28.50 - 62.00[3]
Evapotranspiration	5,400 - 6,500	10.00 - 25.00[2]
Evapotranspiration-Absorption	3,000 - 6,500	10.00 - 25.00[2]
Mound	5,500 - 6,500	28.50 - 62.00[3]
Compost Toilet	800 - 1,600	3.00 - 5.00[4]
Gray Water		
Septic Tank and Disposal Field	600 - 1,600	5.00 - 12.50[5]
Trickle Filter and Disposal Field	200 - 1,200	5.00 - 12.50[5]
Sand Filter and Disposal Field	3,500 - 5,500	22.50 - 50.00[6]

[1] Based on cost of individual components (Table 16-3).
[2] Annual cost based on pumping septic tank every 5 years.
[3] Annual cost based on power at 4¢/KWH, pump replacement every 10 years, and pumping septic tank every 5 years.
[4] Annual cost based on power at 4¢/KWH and fan replacement every 10 years.
[5] Annual cost based on pumping septic tank every 10 years.
[6] Annual cost based on power at 4¢/KWH, pump replacement every 10 years, and pumping septic tank every 10 years.

simplicity of the system. The only operation and maintenance cost was pumping the septic tank every 5 years. Systems installed in saprolite were slightly more expensive to install because saprolite was more difficult to excavate than soil. The steep slope system utilized the same components as the standard system, but the construction cost was considerably higher. This was due to added labor cost associated with installing a disposal field on slopes up to 45%. Hand labor was required to dig most of the disposal trenches and wooden retaining walls were constructed to retain soil backfill on the steep slopes. Gravel filter material and backfill was installed by hand in most systems. Seepage trenches in soils with slow and very slow permeability (Chapter 6) also used the same components as a standard system, but construction costs were higher because deeper trenches were used requiring more gravel filter material. In addition, the fine-textured soils were more difficult to work and more equipment time was required to excavate and backfill seepage trenches.

The tile dewatering system used, in addition to the same components as a standard system, a tile drainage system installed around the disposal field. This increased the construction cost about $2,500.

Sand filter systems were the most expensive to construct, operate, and maintain because of the complexity of the system, cost of additional components (Table 16-3), and operation and maintenance costs. The bottomless intermittent sand filter (Chapter 3) was the least expensive of the sand filters because the sand bed was placed into an excavation in saprolite. No liner was used and no disposal field was installed. Treated effluent discharged

TABLE 16-3. COST OF INDIVIDUAL COMPONENTS OF ON-SITE SEWAGE SYSTEMS

COMPONENT	COST ($)
Septic Tank	350.00 - 450.00
Septic Tank Installation	100.00 - 200.00
Drop Box, Distribution Box	30.00 - 40.00
Disposal Trench (Per Foot)	4.50 - 5.50
Sand and Gravel (Per Yard)	8.50 - 11.00
Concrete (Per Yard in Place)	95.00 - 125.00
Pump	165.00 - 350.00
Electrical Controls	150.00 - 200.00
Pump Tank (Installed)	350.00 - 500.00
Vinyl Liner and Boots	150.00 - 300.00

directly into underlying saprolite. The concrete-lined intermittent sand filter and the concrete-lined intermittent recirculating sand filter were the most expensive. The vinyl-lined recirculating sand filter was intermediate in cost. Construction costs for the mound system were about the same as they were for the viyl-lined intermittent sand filter. Operation and maintenance cost for these systems ranged from $28 to $65 per year (Table 16-2).

Pressure distribution systems were about $1,000 more expensive to install than a standard system because of component costs (Table 16-3) and additional labor costs.

The evapotranspiration system was a proprietary system and the cost was set by the manufacturer. The evapotranspiration-absorption system was expensive because of its size and the amount of gravel filter material used.

An on-site sewage system consisting of a composting toilet and gray water system was more expensive than a standard system because of the cost of the composting toilet.

CONCLUSIONS

The standard system is the most cost-effective and trouble-free system if suitable soils occur on the site. If suitable soils do not occur on-site, a detailed site evaluation report identifies suitable alternative system options. If more than one alternative system is feasible, final selection can be based on cost analyses.

APPENDIX A

OREGON ADMINISTRATIVE RULES

CHAPTER 340 - DEPARTMENT OF ENVIRONMENTAL QUALITY

DIVISION 74

EXPERIMENTAL SEWAGE DISPOSAL SYSTEMS

Statement of Policy

340-74-004 The Environmental Quality Commission recognizes:

(1) Alternative technologies to conventional septic and drainfield sewage disposal systems are needed in areas planned for rural or low density development.

(2) Standards for alternative disposal systems must be developed based on information obtained from a controlled program of field testing and evaluation.

(3) Funds available to the State of Oregon for testing the acceptability of alternative systems are limited. Careful selection of the types and numbers of systems to be studied is necessary.

(4) The testing of alternative systems requires the cooperation of citizens willing to risk investing money on an experimental system which may fail and require replacement.

(5) An experimental program is not intended to serve as the last resort for obtaining an on-site sewage disposal permit where all other attempts to get a permit fail.

(6) Any program of experimentation must be carried out with the recognition failures will occur. Appropriate steps must be taken to insure adequate protection of public health, safety, welfare, and the potential purchasers of properties where experimental systems are installed.

Therefore, it is the policy of the Commission that the Department pursue a program of experimentation to obtain sufficient data for the development of alternative disposal systems, rules and standards which may benefit significant numbers of people in areas of need within Oregon.

Statutory Authority: ORS 454.625

Hist: Filed and Eff. 3-1-78 as DEQ 1-1978

340-74-005 Filed 9-2-75 as DEQ 98,
Eff. 9-25-75
Repealed by DEQ 1-1978,
Filed and Eff. 3-1-78

Definitions

340-74-010 All definitions under ORS 468.700 and OAR 340-71-010 and 340-74-010 shall apply as applicable.

Statutory Authority: ORS 454.625

Hist: Filed and Eff. 3-1-78 as DEQ 1-1978

Minimum Criteria for Selecting Experimental Sites

340-74-011 The Commission recognizes minimum criteria are necessary for selecting experimental disposal systems sites. Sites may be considered for experimental permit issuance where:

(1) Soils, climate, groundwater, or topographical conditions are common enough to benefit large numbers of people. Sites will not be considered for permit where soils, climate, groundwater, or landscape have little in common with other areas.

(2) A specific acceptable backup alternative is available in the event the experimental system fails.

Backup alternatives may include, but are not limited to, repair, expansion, connection to a sewer, installation of a different system, or abandonment of site.

(3) For absorption systems, soils in both original development and expansion areas are similar.

(4) Installation of a particular system is necessary to provide a sufficient data sampling base.

(5) Zoning, planning, and building requirements allow system installation.

(6) A single family dwelling or its waste water producing equivalent will be served.

(7) The permitted system will be used on a continuous basis during the life of the test project.

(8) Resources for monitoring, sample collection, and laboratory testing are available.

(9) Legal and physical access for construction inspections and monitoring are available to the Department.

(10) The property owner will record an affidavit notifying prospective purchasers of the existance of an experimental system.

Statutory Authority: ORS 454.625

Hist: Filed and Eff. 3-1-78 as DEQ 1-1978

Preliminary Experimental System Proposals

340-74-012 The Commission and Department desire to minimize expenses for potential experimental systems applicants until it can be determined there is strong potential a proposal can be accepted for approval. Therefore, the following procedures shall apply:

(1) A preliminary experimental proposal shall be directed to the Department for review to determine if they meet minimum site selection

criteria. The Department will evaluate the proposed experimental site to help determine if it meets minimum site selection criteria.

(2) Where the Department finds a preliminary proposal meets minimum site selection criteria, it will advise the prospective experimental applicant to complete and file an application for permit pursuant to OAR 340-74-015. The Department will advise and assist the applicant to the extent possible in this process.

(3) Where the Department finds minimum site selection criteria are not met, the prospective experimental applicant will be advised against making permit application.

Statutory Authority: ORS 454.625
Hist: Filed and Eff. 3-1-78 as DEQ 1-1978

Permit Required for Construction

340-74-013 Without first obtaining a specifically conditioned permit, from the Department, no person shall construct or install an experimental on-site treatment and disposal system.

Statutory Authority: ORS 454.625
Hist: Filed and Eff. 3-1-78 as DEQ 1-1978

340-74-015 Filed 9-2-75 as DEQ 98,
Eff. 9-25-75
Repealed by DEQ 1-1978,
Filed and Eff. 3-1-78

Procedures for Issuance or Denial of Permits

340-74-016 (1) Application for permit shall be made on forms approved and provided by the Department. All application forms must be completed in full, signed by the applicant or his legally authorized representative, and accompanied by a fee as required under ORS 468.065(2).

Applicants shall include detailed design specifications and plans, all available laboratory or field test data and any additional information the Department considers necessary.

(2) The applicant shall agree in writing to hold the State of Oregon, its officers, employees, and agents harmless of any and all loss and damage caused by defective installation or operation of the proposed experimental disposal system.

(3) The permit shall:

(a) Specify the method and manner of disposal system installation, operation, and maintenance.

(b) Specify the method, manner, and duration of the disposal systems's testing and monitoring.

(c) Identify when and where system inspection.

(d) Require prompt submission of monitoring and test data to the Department.

(e) Require the permittee to have recorded under deed records in the county where the experimental system is located:

(A) An affidavit which informs future purchasers:

(i) That an experimental system has been installed on the site and is undergoing Department evaluation;

(ii) That neither the Commission nor the Department imply, express, or warrant the experimental system will operate satisfactorily; and

(iii) That if the Department finds the experimental system does not operate satisfactorily and as a result threatens to create a public health hazard or pollute state waters, the Department will require the system be repaired so as to function properly, replaced, or be abandoned.

(B) An easement which provides the Department legal access for monitoring the experimental system.

(4) Permits may be issued by the Water Quality Division Administrator when the Department receives a completed experimental application and has determined minimum criteria for experimental site selection can be met.

(5) Permits are not transferable. Permits shall be issued directly to applicants.

(6) System construction and use are required within one (1) year of permit issuance.

(7) If the proposed experimental system is determined ineligible, the Water Quality Division Administrator will notify the applicant of denial of the permit and the reasons for denial.

(8) The decision by the Water Quality Division Administrator to either issue or deny a permit may, upon request, be reviewed by the Director of DEQ. The Director has the prerogative of affirming or reversing the decision, or referring the matter to the Commission for a decision.

Statutory Authority: ORS 454.625
Hist: Filed and Eff. 3-1-78 as DEQ 1-1978

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APPENDIX B

SITE SELECTION CRITEIA, 1978

1. Disposal Trenches in Soils Shallow to Duripans, Saprolite, and Fractured Bedrock

    A. Less Than 15 Inches Annual Precipitation

    Minimum of 12 inches of soil.

    Well drained soils.

    Plane or convex slope at least 100 feet long with a gradient of 25 percent or less.

    B. 15 Inches to 35 Inches Annual Precipitation

    Minimum of 12 inches of soil.

    Well drained soils.

    Plane or convex slope at least 100 feet long with gradient of 20 percent or less.

    C. 35 Inches to 60 Inches Annual Precipitation

    Minimum of 18 inches of soil.

    Well drained soils.

    Plane or convex slope at least 200 feet long with gradient of 20 percent or less.

2. Disposal Trenches in Subsoils with Slow or Very Slow Permeability

    A. Less Than 15 Inches Annual Precipitation.

    Minimum of 24 inches of soil.

    Moderately well or well drained soils.

    Plane or convex slope at least 200 feet long with gradient of 20 percent or less.

B. 15 inches to 25 Inches Annual Precipitation

Minimum of 36 inches fine textured soil.

Moderately well or well drained soils.

Plane or convex slope at least 200 feet long with gradient of 10 to 20 percent.

3. Gray Waste Water Disposal Trenches

Minimum depth to restrictive or impervious layer 18 inches.

Minimum depth to temporarily perched groundwater 18 inches.

Minimum depth to permanent groundwater 48 inches.

Plane or convex slope at least 100 feet long with gradient of 25 percent or less.

For south facing slopes, up to 30 percent.

4. Mound

Permanent water table at least 36 inches below the soil surface.

Temporary water table at least 18 inches below the soil surface.

Minimum of 18 inches of soil to a restrictive or impervious layer.

Plane or convex slope at least 200 feet long with gradient of 12 percent or less.

5. Evapotranspiration System

Potential evapotranspiration exceeds precipitation by at least 5 inches.

Plane or convex slope at least 200 feet long with gradient of 12 percent or less.

6. Evapotranspiration - Absorption System

A. Less Than 15 Inches of Annual Precipitation.

Minimum of 12 inches of soil.

Moderately well and well drained soils.

Plane or convex slope at least 200 feet long with gradient of 15 percent or less.

B. 15 Inches to 25 Inches Annual Precipitation.

Minimum of 18 inches of soil.

Moderately well and well drained soils.

Plane or convex slope at least 200 feet long with gradient of 15 percent or less.

7. Sand Filter Followed by Disposal Trenches

Minimum depth to restrictive or impervious layer 18 inches.

Minimum depth to temporary water 18 inches.

Minimum depth to permanent water 42 inches.

Plane or convex slope at least 100 feet long with gradient of 25 percent or less.

8. Sand Filter in Gravelly Terrace Soils with Duripan

Minimum depth of groundwater 15 feet.

Plane or convex slope at least 100 feet long with gradient of 3 percent or less.

9. Seepage Trenches in Soils on Steep Slopes

Well drained soils.

Permeable soils with no restrictive or impervious layer within 5 feet of soil surface.

Plane or convex slope at least 100 feet long with gradient between 25 percent to 45 percent.

10. Pressure Distribution System in Sandy and Gravelly Soils

A. Soils Less Than 30 Inches Deep to Coarse Grain Materials.

Minimum depth to groundwater 10 feet.

Plane or convex slope at least 100 feet long with gradient of 12 percent or less.

B. Soils with iron cemented duripans that are rippable.

Somewhat poorly to well drained soils.

Soil that is rippable to depth of 48 inches.

Minimum depth to groundwater 10 feet.

Plane or convex slope at least 100 feet long with gradient of 12 percent or less.

11. Disposal Trenches in Drainable Wet Soils

Site must have a natural outlet that will allow a field tile to daylight when installed at least 6 feet deep in the area of the proposed drainfield.

Drainable soils with no restrictive or impervious layer within 6 feet of soil surface.

Plane or convex slope with gradient of 3 percent or less.

12. Low Pressure Distribution in Soils with High Water Tables

A. Silty Clay Loam, Silty Clay, Sandy Clay, and Clay Soil Textures.

30 inches or greater to groundwater utilizing a soil cap.

Less than 45 inches annual precipitation.

Plane or convex slope at least 100 feet long with a gradient of 3 percent or less.

1 acre minimum.

B. Loam, Silt Loam, Clay Loam, and Sandy Clay Loam Soil Textures

36 inches or greater to groundwater utilizing a soil cap.

Less than 45 inches annual precipitation.

Plane or convex slope at least 100 feet long with a gradient of 3 percent or less.

1 acre minimum.

C. Sand, Loamy Sand, and Sandy Loam Soil Textures

42 inches or greater to ground water utilizing a soil cap, or 30 inches to 42 inches to ground water utilizing a soil fill.

Plane or convex slope at least 100 feet long with a gradient of 3 percent or less.

Less than 45 inches annual precipitation.

1 acre minimum for systems utilizing a soil cap.

Sufficient acreage, utilizing soil fills, so that borrow will not be taken closer than 100 feet from the toe of the fill.

APPENDIX C

ON-SITE SEWAGE DISPOSAL RULES

STATE OF OREGON
DEPARTMENT OF ENVIRONMENTAL QUALITY
Oregon Administrative Rules
Chapter 340 - Division 71
Rules 260 - 320
(Alternative Systems)

Rules Current
as of
March 8, 1982

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APPENDIX C

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340-71-260 ALTERNATIVE SYSTEMS, GENERAL.

(1) For the purpose of these rules "Alternative system" means any Commission approved on-site sewage disposal system used in lieu of, including modifications of, the standard subsurface system.

(2) "Sewage Stabilization Ponds" and "Land Irrigation of Sewage" are alternative systems available through the Water Pollution Control Facilities (WPCF) permit program.

(3) Unless otherwise noted, all rules pertaining to the siting, construction, and maintenance of standard subsurface systems shall apply to alternative systems.

(4) General Requirements

(a) Periodic Inspection of Installed Systems. Where required by rule of the Commission, periodic inspections of installed alternative systems shall be performed by the Agent. An inspection fee may be charged.

(b) A report of each inspection shall be prepared by the Agent. The report shall list system deficiencies and correction requirements and timetables for correction. A copy of the report shall be provided promptly to the system owner. Necessary follow-up inspections shall be scheduled.

340-71-265 CAPPING FILLS (Diagram 10)

(1) For the purposes of this rule, "Capping Fill" means a system where the disposal trench effective sidewall is installed a minimum of twelve (12) inches into natural soil below a soil cap of specified depth and texture.

(2) Criteria for Approval. In order to be approved for a capping fill system, each site must meet all the following conditions:

(a) Slope does not exceed twelve (12) percent.

(b) Temporary water table is not closer than eighteen (18) inches to the ground surface at anytime during the year. A six (6) inch minimum separation must be maintained between the bottom of the disposal trench and the temporary water table.

(c) Where a permanent water table is present, a minimum four (4) feet separation shall be maintained between the bottom of the disposal trench and the water table.

(d) Where material with rapid or very rapid permeability is present, a minimum eighteen (18) inches separation shall be maintained between the bottom of the disposal trench and soil with rapid or very rapid permeability.

(e) Effective soil depth is eighteen (18) inches or more below the natural soil surface.

(f) Soil texture from the ground surface to the layer that limits effective soil depth is no finer than silty clay loam.

(g) A minimum six (6) inch separation shall be maintained between the bottom of the disposal trench and the layer that limits effective soil depth.

(h) The system can be sized according effective soil depth in Table 4.

(3) Installation Requirements. The cap shall be constructed pursuant to permit requirements. Unless otherwise required by the Agent, construction sequence shall be as follows:

(a) The soil shall be examined and approved by the Agent prior to placement. The texture of the soil used for the cap shall be of the same textural class, or of one textural class finer, as the natural topsoil.

(b) Construction of capping fills shall occur between June 1 and October 1 unless otherwise allowed by the Agent. The upper eighteen (18) inches of natural soil must not be saturated or at a moisture content which causes loss of soil structure and porosity when worked.

(c) The drainfield site and the borrow site shall be scarified to destroy the vegetative mat.

(d) Drainfield shall be installed as specified in the construction permit. There shall be a minimum ten (10) feet of separation between the edge of the fill and the nearest trench sidewall.

(e) Fill shall be applied to the fill site and worked in so that the two (2) contact layers (native soil and fill) are mixed. Fill material shall be evenly graded to a final depth of sixteen (16) inches over the gravel. Both initial cap and repair cap may be constructed at the same time.

(f) The site shall be landscaped according to permit conditions and be protected from livestock, automotive traffic or other activity that could damage the system.

(4) Required Inspections. The following minimum inspections shall be performed for each capping fill installed:

(a) Both the drainfield site and borrow material must be inspected for scarification, soil texture, and moisture content, prior to cap construction.

(b) Pre-cover inspection of the installed drainfield.

(c) After cap is placed, to determine that there is good contact between fill material and native soil (no obvious contact zone visible), adequate depth of material, and uniform distribution of fill material.

(d) Final inspection, after landscaping. A Certificate of Satisfactory Completion may be issued at this point.

340-71-270 EVAPOTRANSPIRATION-ABSORPTION (ETA) SYSTEMS. (Diagram 6 & 7)

(1) For the purpose of these rules "Evapotranspiration-Absorption System" means an alternative system consisting of a septic tank or other treatment facility, effluent sewer and a disposal bed or disposal trenches, designed to distribute effluent for evaporation, transpiration by plants, and by absorption into the underlying soil.

(2) Criteria for Approval. Installation permits may be issued for evapotranspiration-absorption (ETA) systems on sites that meet all of the following conditions:

(a) Mean annual precipitation does not exceed twenty-five (25) inches.

(b) There exists a minimum of thirty (30) inches of moderately-well to well drained soil. The subsoil at a depth of twelve (12) inches and below shall be fine textured.

(c) Slope does not exceed fifteen (15) percent. Exposure may be taken into consideration.

(3) Criteria for System Design. ETA beds shall be designed under the following criteria:

(a) Beds shall be sized using a minimum eight hundred fifty (850) square feet of bottom surface area per one hundred fifty (150) gallons of projected daily sewage flow in areas where annual precipitation is fifteen (15) to twenty-five (25) inches, or six hundred (600) square feet of bottom surface area per one hundred fifty (150) gallons of projected daily sewage flow in areas where annual precipitation is less than fifteen (15) inches.

(b) Beds shall be installed not less than twelve (12) inches nor deeper than twenty-four (24) inches into natural fine textured soil on the downhill side and not more than thirty-six (36) inches deep on the uphill side.

(c) A minimum of one (1) distribution pipe shall be placed in each bed.

(d) The surface shall to be seeded according to permit conditions.

(e) Other bed construction standards contained in Diagrams 6 and 7 shall apply.

340-71-275 PRESSURIZED DISTRIBUTION SYSTEMS.

(1) Pressurized distribution systems may be permitted on any site meeting requirements for installation of standard subsurface sewage disposal systems, or other sites where this method of effluent distribution is desired.

(2) Except as provided in OAR 340-71-220(2)(c), pressurized distribution systems shall be used where depth to soil as defined in OAR 340-71-105 (84) (a) and (b) is less than thirty (36) inches and the minimum separation distance between the bottom of the disposal trench and soil as defined in OAR 340-71-105 (84) (a) and (b) is less than eighteen (18) inches.

(3) Pressurized distribution systems installed in soil as defined in OAR 340-71-105 (84) (a) and (b) in areas with permanent water tables shall not discharge more than four hundred fifty (450) gallons of effluent per one-half (1/2) acre per day except where:

(a) A gray water system is proposed for lots of record existing prior to January 1, 1974, which have sufficient area to accommodate a gray water pressurized distribution system, or

(b) Groundwater is degraded and designated as a nondevelopable resource by the State Department of Water Resources, or

(c) A detailed hydrogeological study discloses loading rates exceeding four hundred fifty (450) gallons per one-half (1/2) acre per day would not increase the nitrate-nitrogen concentration in the groundwater beneath the site, or at any down gradient location, above five (5) milligrams per liter.

(4) Materials and Construction.

(a) General.

(A) All materials used in pressurized systems shall be structurally sound, durable, and capable of withstanding normal stresses incidental to installation and operation.

(B) Nothing in these rules shall be construed to set aside applicable building, electrical, or other codes. An electrical permit and inspection from the Department of Commerce or the municipality with jurisdiction (as defined in ORS 456.750(5)) is required for pump wiring installation.

(b) Pressurized Distribution Piping. Piping, valves and fittings for pressurized systems shall meet the following minimum requirements:

(A) All pressure transport, manifold, lateral piping, and fittings shall meet or exceed the requirements for Class 160 PVC 1120 pressure pipe as identified in ASTM Specification D2241.

(B) Pressure transport piping shall be uniformly supported along the trench bottom, and at the discretion of the Agent, it shall be bedded in sand or other material approved by the Agent.

(C) Orifices shall be located on top of the pipe, except in areas of extended frozen soil conditions in which case the Agent may specify orifice orientation.

(D) The ends of lateral piping shall be provided with threaded plugs or caps.

(E) All joints in the manifold, lateral piping, and fittings shall be solvent welded, using the appropriate joint compound for the pipe material. Pressure transport piping may be solvent welded or rubber ring jointed.

(F) A gate valve shall be placed on the pressure transport pipe, in or near the dosing tank, when appropriate.

(G) A check valve shall be placed between the pump and the gate valve, when appropriate.

(c) Trench Construction.

(A) Minimum trench length required shall be not less than that specified in Tables 4 and 5.

(B) Drainfield trenches shall be constructed using the specifications for the standard drainfield trench unless otherwise allowed by the Department on a case-by-case basis.

(C) Pressure lateral piping shall have not less than six (6) inches of filter material below, nor less than four (4) inches of filter material above the piping.

(D) The sides of the trench and top of the filter material shall be lined or covered with filter fabric, or other nondegradable material permeable to fluids that will not allow passage of soil particles coarser than very fine sand. In soils finer textured than loamy sand, lining the sidewall may not be required.

(d) Seepage Bed Construction.

(A) Seepage beds may only be used in soil as defined in OAR 340-71-105 (84) (a) and (b) as an alternative to the use of disposal trenches.

(B) The effective seepage area shall be based on the bottom area of the seepage bed. The minimum area shall be not less than that specified in Table 9.

(C) Beds shall be installed not less than eighteen (18) inches (twelve (12) inches with a capping fill) nor deeper than thirty six (36) inches into the natural soil. The seepage bed bottom shall be level.

(D) The top of the filter material shall be lined or covered with filter fabric, or other nondegradable material that is permeable to fluids but will not allow passage of soil particles coarser than very fine sand.

(E) Pressurized distribution piping shall have not less than six (6) inches of filter material below, nor less than four (4) inches of filter material above the piping.

(F) Pressurized distribution piping shall be horizontally spaced not more than four (4) feet apart, and not more than two (2) feet away from the seepage bed sidewall. At least two (2) parallel pressurized distribution pipes shall be placed in the seepage bed.

(G) A minimum of ten (10) feet of undisturbed earth shall be maintained between seepage beds.

(e) Notwithstanding other requirements of this rule, when the projected daily sewage flow is greater than two thousand five hundred (2500) gallons the Department may approve other design criteria and standards it deems appropriate.

(5) Hydraulic Design Criteria. Pressurized distribution systems shall be designed for appropriate head and capacity.

(a) Head calculations shall include maximum static lift, pipe friction and orifice head requirements.

(A) Static lift where pumps are used shall be measured from the minimum dosing tank level to the level of the perforated distribution piping.

(B) Pipe friction shall be based upon a Hazen Williams coefficient of smoothness of 150. All pressure lateral piping and fittings shall have a minimum diameter of two (2) inches unless submitted plans and specifications show a smaller diameter pipe is adequate. The head loss across a lateral with multiple evenly spaced orifices may be considered equal to one-third (1/3) of the head loss that would result if the entrance flow were to pass through the length of the lateral.

(C) There shall be a minimum head of five (5) feet at the remotest orifice and no more than a fifteen (15) percent head variation between nearest and remotest orifice in an individual unit.

(b) The capacity of a pressurized distribution system refers to the rate of flow given in gallons per minute (gpm).

(A) Lateral piping shall have discharge orifices drilled a minimum diameter of one-eighth (1/8) inch, and evenly spaced at a distance not greater than twenty four (24) inches in coarse textured soils or greater than four (4) feet in finer textured soils.

(B) The system shall be dosed at a rate not to exceed twenty (20) percent of the projected daily sewage flow.

(C) The affect of back drainage of the total volume of effluent within the pressure distribution system shall be evaluated for its impact upon the dosing tank and system operation.

340-71-280 SEEPAGE TRENCH SYSTEM.

(1) For the purpose of these rules "Seepage Trench System" means a system with disposal trenches with more than six (6) inches of filter material below the distribution pipe.

(2) Criteria for Approval. Construction permits may be issued by the Agent for seepage trench systems on lots created prior to January 1, 1974, for sites that meet all the following conditions:

(a) Groundwater degradation would not result.

(b) Lot or parcel is inadequate in size to accommodate standard subsurface system disposal trenches.

(c) All other requirements for standard subsurface systems can be met.

(3) Design Criteria. Seepage trench system dimensions shall be determined by the following formula:

Length of seepage trench = (4) (length of disposal trench)/(3 + 2D) where D = depth of filter material below distribution pipe in feet. Maximum depth of filter material (D) shall be two (2) feet.

340-71-285 REDUNDANT SYSTEMS. (Diagram 11)

(1) For the purpose of these rules "Redundant Disposal Field System" means a system in which two (2) complete disposal systems are installed, the disposal trenches of each system alternate with each other and only one system operates at any given time.

(2) Criteria for Approval. Construction installation permits may be issued by the Agent for redundant disposal field systems to serve single family dwellings on sites that meet all the following conditions:

(a) The lot or parcel was created prior to January 1, 1974, and

(b) There is insufficient area to accommodate a standard system.

(3) Design Criteria.

(a) Each redundant disposal system shall contain two (2) complete disposal fields.

(b) Each disposal field shall be adequate in size to accommodate the projected daily sewage flow from the dwelling.

(c) A minimum separation of ten (10) feet (twelve (12) feet on centers) shall be maintained between disposal trenches designed to operate simultaneously, and a minimum separation of four (4) feet (six (6) feet on centers) shall be maintained between adjacent disposal trenches.

340-71-290 SAND FILTER SYSTEMS.

(1) For the purpose of these rules:

(a) "Conventional sand filter" means a filter with two (2) feet of medium sand designed to filter and biologically treat septic tank or other treatment unit effluent from a pressure distribution system at an application rate not to exceed one and twenty-three hundredths (1.23) gallons per square foot sand surface area per day, applied at a dose not to exceed twenty (20) percent of the projected daily sewage flow.

(b) "Medium sand" means a mixture of sand with 100 percent passing the 3/8 inch sieve, 90 percent to 100 percent passing the No. 4 sieve, 62 percent to 100 percent passing the No. 10 sieve, 45 percent to 82 percent passing the No. 16 sieve, 25 percent to 55 percent passing the No. 30 sieve, 5 percent to 20 percent passing the No. 50 sieve, 10 percent or less passing the No. 60 sieve, and 4 percent or less passing the No. 100 sieve.

(c) "Sand filter system" means the combination of septic tank or other treatment unit, a dosing system with effluent pump(s) and controls or dosing siphon, piping and fittings, sand filter, absorption facility or effluent reuse method used to treat sewage.

(2) Inspection Requirements. Each sand filter system installed under this rule, and those filters installed under OAR 340-71-038, may be inspected annually. The Department may waive the annual evaluation fee during years when sand filter field evaluation work is not performed.

(3) Sites Approved for Sand Filter Systems. Sand filters may be permitted on any site meeting requirements for standard subsurface sewage disposal systems contained under OAR 340-71-220, or where disposal trenches (including shallow subsurface irrigation trenches) would be used, and all the following minimum site conditions can be met:

(a) The highest level attained by temporary water would be:

(A) Twelve (12) inches or more below ground surface where gravity equal distribution trenches are used. Pressurized distribution trenches may be used to achieve equal distribution on slopes up to twelve (12) percent; or

(B) Twelve (12) inches or more below ground surface on sites requiring serial distribution where distribution trenches are covered by a capping fill, provided: trenches are excavated twelve (12) inches into the original soil profile, slopes are twelve (12) percent or less, and the capping fill is constructed according to provisions under OAR 340-71-265(3) and 340-71-265 (4)(a) through (c). A construction-installation permit shall not be issued until the fill is in place and approved by the Agent; or

(C) Eighteen (18) inches or more below ground surface on sites requiring serial distribution where standard serial distribution trenches are used.

(b) The highest level attained by a permanent water table would be equal to or more than distances specified below:

	Soil Groups	*Minimum Separation Distance from Bottom Effective Seepage Area
(A)	Gravel, sand, loamy sand, sandy loam	24 inches
(B)	Loam, silt loam, sandy clay loam, clay loam	18 inches
(C)	Silty clay loam, silty clay, clay, sandy clay	12 inches

*NOTE:

Shallow disposal trenches (placed not less than twelve (12) inches into the original soil profile) may be used with a capping fill to achieve separation distances from permanent groundwater. The fill shall be placed in accordance to the provisions of OAR 340-71-265(3) and 340-71-265(4)(a) through (c). A construction-installation permit shall not be issued until the fill is in place and approved by the Agent.

(c) Permanent water table levels shall be determined in accordance with methods contained in subsection 340-71-220(1)(d). Sand filters installed in soils as defined in OAR 340-71-105 (84), in areas with permanent water tables shall not discharge more than four hundred fifty (450) gallons of effluent per one-half (1/2) acre per day except where:

(A) A gray water system is proposed for lots of record existing prior to January 1, 1974, which have sufficient area to accommodate a gray water sand filter system, or

(B) Groundwater is degraded and designated as a non-developable resource by the State Department of Water Resources, or

(C) A detailed hydrogeological study discloses loading rates exceeding four hundred fifty (450) gallons per one-half (1/2) acre per day would not increase nitrate-nitrogen concentration in the groundwater beneath the site, or any down gradient location, above five (5) milligrams per liter.

(d) Soils, fractured bedrock or saprolite diggable with a backhoe occur such that a standard twenty-four (24) inch deep trench can be installed.

(e) Where slope is thirty (30) percent or less.

(4) Minimum Length Disposal Trench Required. The minimum seepage area required for sand filter absorption facilities is indicated in the following table:

Soil Groups	Minimum Length (Linear Feet) Disposal Trench Per One Hundred Fifty (150) Gallons Projected Daily Sewage Flow
	Minimum
(a) Gravel, sand, loamy sand, sandy loam	35
(b) Loam, silt loam, sandy clay loam, clay loam	45
(c) Silty clay loam, silty clay, sandy clay, clay	50
(d) Saprolite or fractured bedrock	50
(e) High shrink-swell clays (Vertisols)	75

NOTE: Sites with saprolite, fractured bedrock, gravel or soil textures of sand, loamy sand, or sandy loam in a continuous section at least two (2) feet thick in contact with and below the bottom of the sand filter, that meet all other requirements of section 340-71-290(3), may utilize either a conventional sand filter without a bottom or a sand filter in a trench that discharges biologically treated effluent directly into those materials. The application rate shall be based on the design sewage flow in OAR 340-71-295(1) and the basal area of the sand in either type of sand filter. A minimum twenty-four (24) inch separation shall be maintained between a water table and the bottom of the sand filter.

(5) Materials and Construction.

(a) All materials used in sand filter system construction shall be structurally sound, durable and capable of withstanding normal installation and operation stresses. Component parts subject to malfunction or excessive wear shall be readily accessible for repair and replacement.

(b) All filter containers shall be placed over a stable level base.

(c) In areas of temporary groundwater at least twelve (12) inches of unsaturated soil shall be maintained between the bottom of the sand filter and top of the disposal trench.

(d) Piping and fittings for the sand filter distribution system shall be as required under pressure distribution systems, OAR 340-71-275.

340-71-295 CONVENTIONAL SAND FILTER DESIGN AND CONSTRUCTION. (Diagrams 8 and 9)

(1) Sewage Flows:

(a) Design sewage flows for a system proposed to serve a commercial facility shall be limited to six hundred (600) gallons or less per day unless otherwise authorized in writing by the Department.

(b) Design sewage flows for a system proposed to serve a single family dwelling shall not be less than four hundred fifty (450) gallons per day, except as provided in subsection (c).

(c) Design sewage flows for a system proposed to receive gray water only from a single family dwelling shall not be less than three hundred (300) gallons per day.

(2) Minimum Filter Area. Sand filters shall be sized based on an application rate of no more than one and twenty-three hundredths (1.23) gallons septic tank effluent per square foot medium sand surface per day.

(3) Sand filter container, piping, medium sand, gravel, gravel cover, and soil crown material for a sand filter system discharging to disposal trenches shall meet minimum specifications indicated in Diagrams 8 and 9 unless otherwise authorized by the Department.

(4) Container Design and Construction.

(a) A reinforced concrete container consisting of floor and walls as shown in Diagrams 8 and 9 is required where water tightness is necessary to prevent groundwater from infiltrating into the filter.

(b) Container may be constructed of materials other than concrete where equivalent function, workmanship, watertightness and at least a twenty (20) year service life can be documented.

(A) Flexible membrane liner (FML) materials must have properties which are at least equivalent to thirty (30) mil unreinforced polyvinyl chloride (PVC) described in OAR 340-73-085. To be approved for filter installation, FML materials must:

(i) Have field repair instructions and materials which are provided to the purchaser with the liner; and

(ii) Have factory fabricated "boots" suitable for field bonding onto the liner to facilitate the passage of piping through the liner in a waterproof manner.

(B) Where accepted for use, flexible sheet membrane liners shall be placed against relatively smooth, regular surfaces. Surfaces shall be free of sharp edges, corners, roots, nails, wire, splinters and other projections which might puncture, tear, or cut the liner. Where a smooth, uniform surface cannot be assured in the field, filter system plans must include specifications for liner protection. A four (4) inch bed of clean sand or a non-degradable filter fabric acceptable to the Agent, shall be used to provide liner protection.

340-71-300 OTHER SAND FILTER DESIGNS.

(1) Other sand filters which vary in design from the conventional sand filter may be authorized by the Department if they can be demonstrated to produce comparable effluent quality.

(2) Pre-Application Submittal. Prior to applying for a construction permit for a variation to the conventional sand filter the Department must approve the design. To receive approval the applicant shall submit the following required information to the Department:

(a) Effluent quality data. Filter effluent quality samples shall be collected and analyzed by a testing agency acceptable to the Department using procedures identified in the latest edition of "Standard Methods for the Examination of Wastewater," published by the American Public Health Association, Inc. The duration of filter effluent testing shall be sufficient to ensure results are reliable and applicable to anticipated field operating conditions. The length of the evaluation period and number of data points shall be specified in the test report. The following parameters shall be addressed:

(A) BOD_5

(B) Suspended solids

(C) Fecal coliform

(b) A description of unique technical features and process advantages.

(c) Design criteria, loading rates, etc.

(d) Filter media characteristics.

(e) A description of operation and maintenance details and requirements.

(f) Any additional information specifically requested by the Department.

(3) Construction Procedure. Following pre-application approval, a permit application shall be submitted in the usual manner. Applications shall include applicable drawings, details and written specifications to fully describe proposed construction and allow system construction by contractors. Included must be the specific site details peculiar to that application, including

soils data, groundwater type and depth, slope, setbacks, existing structures, wells, roads, streams, etc. Applications shall include a manual for homeowner operation and maintenance of the system.

340-71-305 SAND FILTER SYSTEM OPERATION AND MAINTENANCE.

(1) Sand filter operation and maintenance tasks and requirements shall be as specified on the Certificate of Satisfactory Completion. Where a conventional sand filter system or other sand filter system with comparable operation and maintenance requirements is used, the system owner shall be responsible for the continuous operation and maintenance of the system.

(2) The owner of any sand filter system shall provide the Agent written verification that the system's septic tank has been pumped at least once each forty-eight (48) months by a licensed sewage disposal service business. Service start date shall be assumed to be the date of issuance of the Certificate of Satisfactory Completion. The owner shall provide the Agent certification of tank pumping within two (2) months of the date required for pumping.

(3) No permit shall be issued for the installation of any other sand filter which in the judgment of the Department would require operation and maintenance significantly greater than the conventional sand filter unless arrangements for system operation and maintenance meeting the approval of the Director have been made which will ensure adequate operation and maintenance of the system. Each permitted installation may be inspected by the Agent at least every twelve (12) months and checked for necessary corrective maintenance. The Agent may waive the annual system evaluation fee during years when the field evaluation work is not performed.

340-71-310 STEEP SLOPE SYSTEMS.

(1) General conditions for approval. On-site system construction permits may be issued by the Agent for steep slope systems on slopes in excess of thirty (30) percent provided all the following requirements can be met:

(a) Slope does not exceed forty-five (45) percent.

(b) The soil is well drained with no evidence of saturation.

(c) The soil has a minimum effective soil depth of sixty (60) inches.

(2) Construction requirements.

(a) Seepage trenches shall be installed at a minimum depth of thirty (30) inches and at a maximum depth of thirty-six (36) inches below the natural soil surface on the downhill side of the trench, and contain a minimum of eighteen (18) inches of filter material and twelve (12) inches of native soil backfill.

(b) The system shall be sized at a minimum of one hundred (100) linear feet per one hundred fifty (150) gallons projected daily sewage flow.

340-71-315 TILE DEWATERING SYSTEM.

(1) General conditions for approval. On-site system construction permits may be issued by the Agent for tile dewatering systems provided the following requirements can be met:

(a) The site has a natural outlet that will allow a field tile (installed on a proper grade around the proposed drainfield area at a depth of not less than sixty-six (66) inches) to daylight above annual high water.

(b) Soils must be silty clay loam or coarser textured and be drainable, with a minimum effective soil depth of at least sixty-six (66) inches.

(c) Slope does not exceed three (3) percent.

(d) All other requirements for standard on-site systems, except depth to groundwater, can be met.

(2) Construction Requirements.

(a) Field collection drainage tile shall be installed a minimum of sixty-six (66) inches deep on a uniform grade of two-tenths to four-tenths (0.2-0.4) feet of fall per one hundred (100) feet.

(b) Maximum drainage tile spacing shall be seventy (70) feet center to center.

(c) Minimum horizontal separation distance of drainage tile from disposal trenches shall be twenty (20) feet center to center.

(d) Field collection drainage tile shall be rigid smooth wall perforated pipe with a minimum diameter of four (4) inches.

(e) Field collection drainage tile shall be enveloped in clean filter material to within thirty (30) inches of the soil surface. Filter material shall be covered with filter fabric, treated building paper or other nondegradable material approved by the Agent.

(f) Outlet tile shall be rigid smooth wall solid PVC pipe with a minimum diameter of four (4) inches. The outlet end shall be protected by a short section of Schedule 80 PVC or ABS or metal pipe, and a flap gate.

(g) A silt trap with a thirty (30) inch minimum diameter shall be installed between the field collection drainage tile and the outlet pipe. The bottom of the silt trap shall be a minimum twelve (12) inches below the invert of the drainage line outlet.

(h) The discharge pipe and dewatering system is an integral part of the system.

(i) The Agent has the discretion of requiring demonstration that a proposed tile dewatering site can be drained prior to issuing a construction installation permit.

340-71-320 SPLIT WASTE SYSTEMS.

(1) For the purpose of these rules:

(a) "Split waste system" means a system where "black waste" sewage and "gray water" sewage from the same dwelling or building are disposed of by separate methods.

(b) "Black waste" means human body wastes including feces, urine, other extraneous substances of body origin and toilet paper.

(c) "Gray water" means household sewage other than "black wastes", such as bath water, kitchen waste water and laundry wastes.

(2) Criteria for Approval. In split waste systems wastes may be disposed of as follows:

(a) Black wastes may be disposed of by the use of state Department of Commerce approved nonwater-carried plumbing units such as recirculating oil flush toilets or compost toilets.

(b) Gray water may be disposed of by discharge to:

(A) An existing on-site system which is not failing; or

(B) A new on-site system with a soil absorption system two-thirds (2/3) normal size. A full size initial drainfield area and replacement area of equal size are required; or

(C) A public sewerage system.

APPENDIX D

SITE SELECTION CRITERIA, 1981

1. Disposal Trenches in Drainable Soils with High Water Tables

    A. Permanent Groundwater

    Site must have a natural outlet that will allow a field tile to daylight when installed at least 4 feet deep in the area of the proposed drainfield.

    Drainable soils with an effective soil depth of 4 feet.

    Plane or convex slope with gradient of 3 percent or less.

    Pressure Distribution = 80 feet/150 gallons

    Gravity Distribution = 100 feet/150 gallons

    B. Temporary Groundwater

    Site must have a natural outlet that will allow a field tile to daylight when installed at least 2 1/2 feet deep in the area of the proposed drainfield.

    Drainable soils with an effective soil depth of 2 feet.

    Plane or convex slope with gradient of 30 percent or less.

    Pressure Distribution = 80 feet/150 gallons

    Serial Distribution = 100 feet/150 gallons

2. Seepage Trenches in Soils on Steep Slopes

    A. Less than 25 inches annual precipitation

    Well drained, permeable soils with an effective soil depth of 2 1/2 feet.

Plane or convex slope at least 100 feet long with gradient up to 45 percent.

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50 feet-30 inch (18 inches gravel and 12 inches backfill) serial seepage trench/150 gallons.

B. Greater than 25 inches annual precipitation

Well drained permeable soils with an effective soil depth of 3 1/2 feet.

Plane or convex slope at least 100 feet long with gradient up to 45 percent.

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50 feet-30 inches (18 inches gravel & 12 inches backfill) serial seepage trench/150 gallons.

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3. Seepage Trenches in Soils with Slow or Very Slow Permeability

A. 15 inches annual precipitation

Minimum of 24 inches of fine textured soil.

Moderately well or well drained soils.

Plane or convex slope with gradient of 30 percent or less.

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100 feet 36 to 42 inch (2 feet (minimum) gravel & 12 inches backfill) serial seepage trench/150 gallons.

B. 15 to 40 inches annual precipitation

Minimum of 36 inches fine textured soil.

Moderately well or well drained soils.

Plane or convex slope with gradient of 10 to 30 percent.

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150 feet 36 to 42 inch (2 feet (minimum) gravel & 12 inches backfill) serial seepage trench/150 gallons.

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4. Disposal Trenches in Soils Shallow to Duripans, Saprolite, or Fractured Bedrock

   A. Less than 15 inches annual precipitation

      Minimum of 6 inches of soil diggable to a depth of 24 inches.

      Well drained soils.

      Plane or convex slope with a gradient of 30 percent or less.

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100 feet serial disposal trench/150 gallons.

   B. 15 Inches to 40 Inches Annual Precipitation

      Minimum of 12 inches of soil diggable to a depth of 24 inches.

      Well drained soils.

      Plane or convex slope with gradient of 30 percent or less.

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125 feet serial disposal trench/150 gallons.

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5. Disposal Trenches with Low Pressure Distribution in Soils with High Water Tables

   A. Disposal Trenches in Natural Soil

      1. Sand, loamy sand, and sandy loam soil textures.

         Minimum depth to groundwater 4 feet.

         Plane or convex slope with a gradient of 3 percent, or less.

      2. Loam, silt loam, clay loam, and sandy clay loam soil textures.

         Minimum depth to groundwater 3 1/2 feet.

         Plane or convex slope with a gradient of 3 percent, or less.

3. Silty clay loam, silty clay, sandy clay, and clay soil textures.

   Minimum depth to groundwater 3 feet.

   Plane or convex slope with a gradient of 3 percent or less.

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80 feet pressure distribution trench/150 gallons.

B. Disposal Trenches Utilizing a 12 Inch Soil Cap

1. Sand, loamy sand, and sandy loam soil textures.

   Minimum depth to ground water 3 feet.

   Plane or convex slope with a gradient of 3 percent or less.

2. Loam, silt loam, clay loam, and sandy loam soil textures.

   Minimum depth to ground water 2 1/2 feet.

   Plane or convex slope with a gradient of 3 percent or less.

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80 feet pressure distribution trench/150 gallons.

C. Disposal Trenches Utilizing a Soil Fill

1. Sand, loamy sand, and sandy loam soil textures.

   Minimum depth to ground water 2 feet.

   Similar kind of soil borrow available to install a fill 2 feet thick.

   Plane or convex slope with a gradient of 3 percent or less.

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80 feet pressure distribution trench/150 gallons.

APPENDIX E

PROGRESS REPORT
COMPOSTING TOILETS
February 28, 1978

By February 28, 1978, the Department of Environmental Quality had issued 33 permits for composting toilets and gray wastewater treatment and disposal systems under the Experimental On-Site Program.

Staff contacted 22 permittees between February 3 and March 3, 1978. At that time, 4 individuals stated they elected not to install their permitted experimental systems, 12 had not completed construction on their homes, 11 compost toilets were in use, and 1 family had their compost toilet (Biu-Let) removed because of odor and liquid buildup problems.

Of the 11 units in use, 4 had fly problems (3 Clivus Multrums and 1 Toa-Throne) during the summer months; 5 had odor problems (4 Ecolets and 1 Biu-Let); 7 have had liquid problems (2 Biu-Lets, 4 Ecolets and 1 Clivus Multrum; twice, rising seasonal water tables leaked through an air intake of 1 Clivus Multrum's compost chamber, filling the lower portion of the chamber); and 1 Biu-Let became dehydrated (the owner had to add tap water to the system from time-to-time).

The Department had issued permits for:

4	Toa-Thrones
19	Clivus Multrums (2 Toilets Authorized Under 1 Permit)
4	Biu-Lets
10	Ecolets (3 Toilets Authorized Under 1 Permit and 2 on Another)
1	Drum Privy

The following toilets were in use:

1	Toa-Throne
5	Ecolets
1	Biu-Let
4	Clivus Multrums

APPENDIX F

PROGRESS REPORT
COMPOSTING TOILETS

January 30, 1979

By January 30, 1979, 39 permits authorizing 42 compost toilet installations had been issued under DEQ's Experimental Program.

Four individuals decided not to install their permitted toilets; 1 had been deleted from the experimental program, and 11 people had not installed their permitted toilets, but intended to do so.

Twenty-eight toilets were installed. They included:

2	Biu-Lets
3	The Compost Toilets
9	Ecolets
2	Toa-Thrones
11	Clivus Multrums
1	Drum Privy

Twenty toilets were in use; 2 had recently been installed and would soon be used; and 5 toilets, 1 Biu-Let and 4 Ecolets, were removed after owners encountered severe operating difficulties.

In late December and early November 1978, twenty-three permittees who had installed toilets were asked to complete a questionnaire to determine their impression of toilet performance.

The following was reported:

I Flies - Fly problems were evident, especially when toilets were initially used by 15 individuals. Toilets involved included:

7	Ecolets
2	The Compost Toilets
4	Clivus Multrums
2	Toa-Thrones

II Other insects - In 31 instances, insects other than flies were observed in:

1	Ecolet (gnats)
2	Clivus Multrums (spiders)

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III Excess liquid buildup was reported in 16 toilets

2	Biu-Lets
7	Ecolets
1	The Compost Toilet
1	Toa-Throne
5	Clivus Multrums

Owner estimates of excess liquid volumes were:

2 Biu-lets

- 1 unit filled to the top of the unit. The toilet was later removed by the owner.

- 1 unit accumulated approximately 1 gallon excess liquid in the front compost retrieval tray each month while its back tray remained dry. The owner had to remove excess liquid at 2-month intervals.

1 The Compost Toilet

- The owner reported 5 to 10 gallons excess liquid buildup per month.

7 Ecolets

- 3 units filled to their tops. All were removed after several bailings failed to control excess buildup problems.

- 2 units trays filled and had to be emptied by owners.

- 1 user reported a 1 to 1-1/2 gallon buildup following initial use.

- Another owner has had to remove 3 gallons of excess liquid.

1 Toa-Throne

- The amount was not reported. The system owner concluded moisture entered the toilet as rainfall through the unit's vent stack.

5 Clivus Multrums

- 1 person had to remove 40 gallons twice. He attributed buildup to rainfall and condensation entering the vent stack.

- 1 individual reported a 4" liquid buildup in the base of the unit after startup. The level subsided with continued toilet use.

- 1 owner has removed approximately 10 gallons of liquid twice. He attributed liquid excess to periodic heavy use by several people.

- 1 person removed 20 gallons he felt resulted from rainfall entering the vent stack.

- 1 unit had to be bailed twice (approximately 40 gallons each time) after seasonally perched groundwater entered through its air intakes.

IV Excess waste accumulation was reported by 6 owners using:

1 Biu-Let

- The unit filled to the top. The toilet was removed by the owner.

5 Ecolets

- 1 unit filled partially. The owner had to remove excess material.

- 4 units filled to the top. All were eventually removed by their owners.

V Compost was removed from the retrieval trays of 1 Biu-Let every 4 months. Some composted material was removed by a Toa-Throne user.

VI Owners report using the following materials as carbon sources:

Material	No. Using Material
Woodshavings, barkdust or sawdust	9
Kitchen Scraps	14
Peat Moss	18
Grass/Hay Clippings	2
Garden Litter	6

VII Cost estimates for toilets - Costs include the amount paid to purchase the unit in 1979. In some instances, installation costs are included.

Toilet	Average Cost
Biu-Let	$ 613
The Compost Toilet	1400
Ecolet	670
Toa-Throne	1000
Clivus Multrum	1415
Drum Privy	50

APPENDIX G

PROGRESS REPORT
Composting Toilets
December 18, 1979

In January 1979, the Department conducted a third survey on composting toilet performance.

33 of 21 compost toilet users surveyed responded to a Department questionnaire. Respondents represented the following toilets:

Type	Number
Ecolet	6
The Compost	5
Clivus Multrum	9
Carousel	2
Biulet	1
Drum Privy	1

The toilets had been installed 3 to 42 months, and had been in use an average of 19.3 months.

The total cost for materials and installation ranged from $50 to $3,200 with an average of $1,058.

Materials placed in these units as carbon source materials included:

Material	Responses
Peat Moss	12
Straw	6
Trash	2
Garbage	12
Garden Debris	9
Other	6

Responses to questions about insect pests and their frequency of occurrence follow:

Pest	Constant	Intermittent	Initially	Once or Twice	None
Fruit Flies	0	3	2	7	5
House Flies	0	2	1	2	12
Spiders	1	0	0	1	15
Beetles	0	0	1	0	16

Problems with insect pests occurred during the following months:

Time	Responses
June	5
July	6
August	5
September	2
February	1

In addition, 1 person reported problems during periods when his toilet was not in use and another noticed insects after adding grass clippings.

Insect presence was reported as follows:

Status	Responses
Disappeared Naturally	4
Eliminated by Pesticides	9
Remain all the time	2

The following pesticides were used by toilet owners:

Shell No-Pest Strips	4
Baytex	1
Rotenone	2
Ortho	1
Black Flat	2
Pyrethrin	1
Fly Paper	1

Excess liquid buildup was reported by 11 people, no buildup by 5.

2 people reported having had to remove and bury excess mass waste materials.

15 users reported they could detect odors; 2 reported no obvious odors.

Odors were charcterized as:

Earthy	6
Sulfurous	1
Septic Tank Odor	1
Rotting Garbage	3
Other (not able to describe)	4

Odors detected:

Inside the Toilet	9
Outside, Near Toilet	1
When Compost Collection Hatch was Opened	3
Outside Near Toilet Vent Stack	7
Other (undefined)	2

Toilet users were asked to express their views on overall toilet acceptance. The following responses were reported:

The ratings were:

Rating	Corresponding Number
Uncertain	7
Unacceptable	1
Poor	2
Good	3
Very Good	4
Excellent	11

Users were asked if they would install a "composting toilet" in their next home. The following responses were received:

Response	No. Responding
Yes	12
No	2
Not Certain	2
Yes, as a backup toilet only	1